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339	Recycling and local use of materials at Fornebu	Brit Sylte	Products	Barriers and Processes with Recycling
342	Your Home – Australia's new sustainable home design guide	Anthony Marker	Buildings	The Design Process
343	Negotiating a green mindset	Barbra Batshalom	Buildings	The Design Process
344	Successful strategies for market transformation	Barbra Batshalom	Business	Investors and Investment Strategies
347	Recycling of construction waste - barriers to Success	A.O'Rourke	Products	Barriers and Processes with Recycling
349	Weighting health risks in buildings and outdoor environment	Ulla Westerberg	Buildings	Green Building Assessments
350	Life-cycle assessment of PVC-U joinery profiles	Leslie Flanagan	Buildings	Life Cycle Assessments
351	Environmental service product package for real estate sector	Karoliina Vahala	Buildings	The Building Process
353	CRISP Network on Construction and City related Sustainability Indicators: Structuring of Indicators and status of work	Tarja Häkkinen	Buildings	Indicators
355	GB Tool: Scope for User-Interface project assistance (Diversifying the end-use)	Shailja Chandra	Buildings	Green Building Assessments
356	What environmental data do property managers have on buildings and their management?	Liane Thuvander	Buildings	Facility Management
360	Principles of a sustainable urban structure	Thomas Macoun	Cities	Infrastructure
362	Environmental supply chain management at Skanska in Sweden	Karin Jönsson	Products	Harmful Substances
363	Experimental modelling of deciduous climbing plants as shading devices	Marta Hoi Yan Lam	Buildings	Windows and Solar Shading
365	Experimental modelling of a solar thermal storage system for the sustainable space heating of residential buildings	Jonathan Gates	Buildings	Energy – Residential Buildings
366	Transparent and sustainable buildings	Diana Avasoo	Buildings	Facades
368	Erie-Ellington Homes: A new paradigm sustainable urban low income housing	Mark Kelley	Buildings	Designing Houses
369	Double-wall with integrated functions resulting in an energy-saving building	Jan Brataas	Buildings	Facades
370	The environmental effects of an improved thermal envelope adoptions to future regulations	Anders Almgren	Buildings	Reuse of Existing Buildings
371	Long-term leaching of environmentally hazardous substances in admixtures, emitted from concrete	Åse Andersson	Products	Harmful Substances
372	Harmful compounds in paint leached from wooden facades	Åse Andersson	Products	Harmful Substances

373	Thermal comfort; operative temperature in the sun	Ida Bryn	Buildings	Designing Commercial Buildings
374	Strategies for sustainable building and urban development in Malmö; exemplified with Västra Hamnen and Augustenborg	Tor Fossum	Cities	Creating Sustainable Cities
375	Indicators as a planning tool for urban residential areas	Roland Zinkernagel	Buildings	Indicators
376	Benchmarking for sustainable urban development in Malmö - Using a structured comparison as a pre-study	Malin Åberg	Cities	Creating Sustainable Cities
377	Key factors and indicators – how do we use them?	Eva Dalman	Cities	Decision Making
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384	Green aluminium - sustainable office buildings with aluminium facade constructions	Harald Schulz	Buildings	Designing Commercial Buildings
385	Energy saving facades for tropical and subtropical regions	Philipp Müller	Buildings	Facades
387	Climate change mitigation and adaptation tools for homes & offices in New Zealand	Rachel Hargreaves	Buildings	Tools and Guidelines for Sustainable Design
388	A better environment depends on how our buildings are operated – growth and greater welfare can go hand in hand	Ib Steen Olsen	Buildings	Facility Management
389	Building with cardboard: the reality	Andrew Cripps	Buildings	Designing Commercial Buildings
391	The recovery of the building known as “Mill of Ca La Daniela” S.XIX	Pere Alavedra	Buildings	Reuse of Existing Buildings
392	The protection and recovery of the architectonic heritage of the Xix Century in the City of Sabadell (Spain)	Oriol Civil	Cities	Creating Sustainable Cities
394	Integrated LCA-tool in design projects	Erja Reinikainen	Buildings	The Design Process
396	Life cycle based procurement method	Erkki Aho	Business	Investors and Investment Strategies
397	Construction management model for sustainable kindergartens	Jukka Forsman	Buildings	Facility Management
398	Implementing of environmental manual for service buildings	Pälvi Holopainen	Buildings	Facility Management

399	Life cycle competition for heat, ventilation, air-condition and plumbing system	Aimo Hämäläinen	Business	Competitive Advantages
400	Using energy life cycle costs as an instrument for optimization	Hugo Hens	Business	Competitive Advantages
401	Promotion of corporation's energy efficiency and developing a tracking system	Juha Tiuraniemi	Buildings	Facility Management
402	Identification of PCB and decontamination of PCB-containing buildings in Norway	Steinar Amlo	Products	Harmful Substances
404	Quantifying uncertainty in whole building assessment methods	Shailja Chandra	Buildings	Green Building Assessments
405	Toolbox for eco-friendly living	Niina Savolainen	Buildings	Facility Management
406	LCA in the cement and concrete industry. The process of implementing sustainability issues in a chain of industries	Agnes Schuurmans	Products	Reducing Environmental Load from Concrete
407	Comparison of four life cycle based environmental assessment tools of buildings, real estates and infrastructures	Getachew Assefa	Buildings	Green Building Assessments
413	Integration of daylighting, lighting control and HVAC system design in Concordia Engineering building	Andreas K. Athienitis	Buildings	Energy in Commercial Buildings
414	Various aspects of demolition and recycling	Steinar Amlo	Products	Barriers and Processes with Recycling
415	Towards sustainability in the residential sector - A study of future energy use in the Norwegian Dwelling Stock	Lars Myhre	Buildings	Energy Statistics
416	Guidance for environmental assessment of building products	Kristin Holthe	Products	Tools and Guidelines for Choosing Building Materials
420	Dynamic enclosure approach for a building as a power plant	Christoph Nolte	Buildings	Energy – Heating and Cooling
422	A national rating system (LEED™ 2.0) as source of benchmarks and data for GBTool	Dagmar B. Epsten	Buildings	Green Building Assessments
424	Sustainable working place - concept/model, case Aleksis Kiven katu 9	Juha Olkinuora	Buildings	Designing Commercial Buildings
427	Environmental indicators for the building sector - user questionnaires as a basis for indoor indicators	Mauritz Glaumann	Buildings	Indicators
428	Closing the cycle of building materials - recycling construction and demolition waste by quality improvement	Weihong Xing	Products	Various Materials
430	Creating publicly available LCI data modules: An up-date of the US LCI database project	Wayne B. Trusty	Products	Tools and Guidelines for Choosing Building Materials
431	Integrating LCA Tools in green building rating systems	Wayne B. Trusty	Buildings	Labelling

432	European eco-evaluations of construction - an Italian approach	Allessandro Frezza	Buildings	Assessment Tools and LCA
433	Reducing energy & CO_2 emissions - impact and opportunities attributable to Australian suburban dwellings	Allan Rodger	Buildings	Energy – Residential Buildings
435	Three visions of the future urban environment in Australasia	Karen Bayne	Cities	Creating Sustainable Cities in Developing Countries
436	From the shopfront to the street – the future for wooden buildings in a sustainable world	Karen Bayne	Products	Various Materials
437	Comprehensive assessment system of building environmental efficiency in Japan (CASBEE-J)	Shuzo Murakami	Buildings	Green Building Assessments
438	Insulation for sustainability - guidelines and standards	Robert Webb	Buildings	Tools and Guidelines for Sustainable Design
440	Sustainable building material products from bio-fibre raw materials	Bengt Svennerstedt	Products	Various Materials
441	The use of recycled concrete aggregates in the Norwegian building and construction industry	Jacob Mehus	Products	Reducing Environmental Load from Concrete
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443	Model for integrated environmental management system in the design phase	Endre Grimsmo	Buildings	The Design Process
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452	Eco-Office Tower: Navan Credit Union: Ireland	Paul Leech	Buildings	Designing New Buildings
455	A simulation game for sustainable decision making	Igor Mayer	Cities	Decision Making
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459	Combining theory with practice: the development of the QUT Centre for smart and sustainable construction	J Yang	Buildings	Designing School Buildings
461	Tracking sustainable benefits: Municipal projects by the city of Seattle	Teresa Burrelsmann	Cities	Creating Sustainable Cities
463	Green architecture is enhanced through cultural connections with the environment	Patricia Glanville	Buildings	Superior
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466	Introducing practically the environmental concern when prescribing construction products	Jacques Chevalier	Buildings	The Building Process
468	New system for optimized maintenance planning for Oslo municipality's dwellings	Guri Krigsvoll	Cities	Creating Sustainable Cities
469	Total LCC and sustainable construction	Olavi Tupamäki	Business	Competitive Advantages
471	Climate change - adaptation, mitigation and the search for integrated response strategies	Robert Lowe	Business	Policy
473	Introduction of environmental management in an organisation that develops, builds and manages property for government purposes: a process of change!	Zdena Cervenka	Business	Competitive Advantages
474	Environmental guidelines for the Olympic villages of Torino 2006	Bernardo Ruggieri	Buildings	Tools and Guidelines for Sustainable Design
475	Educating of built environment professionals for sustainability	Víctor M. Lopez	Buildings	Education and Research
476	Defining UK dwelling performance standards for 2008: the St. Nicholas Court field trial - reflections on design process	Robert Lowe	Buildings	The Design Process
478	In search for environmental impacts with beneficial effects for the client	Veijo Majava	Business	Competitive Advantages
480	Sun shading as energy and environmental efficiency measure	Ida Bryn	Buildings	Windows and Solar Shading
481	Linking the GBTool to the design and decision-making process	Murray Hall	Buildings	The Design Process
483	Development of a sector sustainability strategy for the UK steel construction industry	Colin V. Honess	Business	Competitive Advantages
484	Rehabilitation of sea side harbors in respect to sustainable development on the base on chosen small resort towns on peninsula Hel in Poland	Maria Stawicka Wałkowska	Cities	Creating Sustainable Cities
485	Value propositions for green buildings	Jerry Yudelson	Business	Investors and Investment Strategies
486	The local Agenda 21 for the old Aleppo: towards a sustainable urban settlement	Maan Chibli	Cities	Creating Sustainable Cities
489	Exergy needs for winter ventilation in buildings	Elisa C. Boelman	Buildings	Energy – Heating and Cooling
490	Flexible buildings and cellulose insulation	Stefan Hulsbosch	Products	Various Materials
494	Environmental sustainability assessment of buildings using requirements in building energy codes	Sam C. M. Hui	Business	Policy
495	Analysis of visual grading and comparison of strength properties of salvaged lumber to virgin lumber	Abdol R. Chini	Products	Various Materials

498	Heliodons for architects' offices	K P Cheung	Buildings	Windows and Solar Shading
499	Sustainable energy use in dwellings – Will the energy use increase with time?	Carolina Hiller	Buildings	Reuse of Existing Buildings
500	Electrochromic windows as a chance to improve energy saving in office buildings in mild climates	F. Gugliermetti	Buildings	Windows and Solar Shading
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518	International cooperative research and development on sustainable urban management by conversion of buildings. Part 1: Research concept	Kouichi Sato	Buildings	Reuse of Existing Buildings
521	The right building in the right place	Jon Kristinsson	Buildings	Superior
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524	Ecosystem services as criteria for green building assessment	Victor Olgyay	Buildings	Green Building Assessments
526	Unlocking the value in sustainable buildings	Caroline Mackley	Business	Investors and Investment Strategies
529	Preschools buildings in a hot climate	Andrea Griborio	Buildings	Education and Research
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538	Program of sustainable designing and building of Moscow	Alexander Tetior	Cities	Decision Making
539	Architecturally - building ecology as part of sustainable building - most important science of 21st century for guaranteeing of sustainable development of cities	Alexander Tetior	Buildings	Superior
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541	Promotion of low cost green buildings - Integration of Bamboo and renewable energy technology	Lin Gan	Products	Various Materials
544	Built in 2020: Futuristic pictures and stories for tomorrow's building	Robert Lechner	Buildings	Designing Houses
545	Residential dreams - Quality criteria for the innovation-oriented housing sector from the users' point of view	Robert Lechner	Buildings	Designing Houses
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548	Green merit card for sustainable living in cities: Development of a model for Asian cities	Mahua Mukherjee	Cities	Creating Sustainable Cities
549	EC draft directive on energy performance: impact for the European building sector	Milou Beerepoot	Buildings	Energy in Houses
550	German guideline for sustainable design	Wolfgang Ornth	Buildings	Tools and Guidelines for Sustainable Design
552	Recycling building materials by taking buildings apart instead of demolition	Ad Roovers	Products	Barriers and Processes with Recycling
553	Different aspects of slum improvement problems	Ratka Colic	Cities	Creating Sustainable Cities
555	Sustainable building assessment methods in South Africa: an agenda for research	Richard Hill	Buildings	Assessment Tools and LCA
556	Towards sustainable buildings in Turkey with special reference to energy efficiency and aseismic design	Ertan Özkan	Buildings	Building Physics
558	Effective technical solutions for sustainable offices - a focus on building materials	Martijn Arets	Products	Various Materials
559	Green building assessment in China: Present and Future	Qian Shi	Buildings	Green Building Assessments
560	Evaluation of double skin glass facades in term of cost efficiency with respect to energy consumption	Ikbal Cetiner	Buildings	Energy in Commercial Buildings
561	Thermal environment and exergy analysis of a ceiling radiant cooling system	Hideo Asada	Buildings	Energy – Heating and Cooling
562	Csiro Energy Centre, Newcastle, New South Wales, Australia	Trevor Moody	Buildings	Education and Research

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565	The thermal comfort management and the transfer of knowledge by means of tools and intelligent environments	Abdelaziz Boukara	Buildings	The Design Process
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571	Building and construction industry in a paradigm shift?! - Status and driving forces in Norway	Sigve J. Aasebø	Business	Policy
572	Ultimat - Building insulation from waste textiles	Tormod Aurlien	Products	Various Materials

Impacts of a Green Building Rating System on the Design and Construction Process: A Summary of Ten Projects Using LEED™

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1. INTRODUCTION

This paper discusses the experience of developing designs for, and the specific sustainability approaches taken by, ten buildings that have used the US Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED™) Green Building Rating System. It identifies the principal ways that LEED™ influenced the design, including the addition of sustainability features, of each of the buildings relative to the design that would otherwise have been produced by "standard practice." It provides a generalization of lessons learned from the projects and describes the extent of market transformation achieved through the LEED™ process.

2. TEN LEED™ BUILDINGS

The ten LEED™ buildings are described in Table 1. Seven of the buildings are currently either in the design phase or under construction; the other three are now fully occupied. Two of the buildings are already officially certified by the USGBC at the "Certified" level. The rest of the buildings are still in the certification process, so the LEED™ level shown is not official. Four buildings intend to achieve the highest LEED™ level of "Platinum," and the last four intend to achieve "Silver" certification. The table lists the major sustainability project features, in the LEED™ system categories: Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, Indoor Environmental Quality, and Innovation & Design Process.

Construction types include new, renovation, expansion, and tenant interior work. The buildings range in size from 455 m^2 to 57,000 m^2 (5,000 to 630,000 square feet) in floor area. Sites include urban and rural areas, as well as a degraded urban city park. Building owners include local and federal government agencies, non-profit and environmental organizations, and major corporations.

2.1 Original Project Designs

The original "base case" project designs for the buildings all included a certain degree of sustainability. Some of the projects by environmentally sophisticated owners would have included some sustainability measures regardless of whether the LEED™ rating system was used or not, as shown in the Base Case. However, as a result of using the LEED™ rating system, these projects have added additional sustainability measures that they otherwise may not have.

Sustainable design is new to the corporate, for-profit owners of the projects. The LEED™ rating system provided them with a valuable tool to evaluate the most cost-effective sustainability measures to include in their projects. This relative cost-effectiveness metric (cost per LEED™ credit) is a key determining factor for decision-making in the corporate world.

2.2 Sustainable Design Review and the Decision Making Process

For each building, determining which sustainability measures to include required close coordination between the entire project team – owner, designers, contractors and consultants. Generally the team determines which sustainability measures to include in the design as a minimum in the design, meaning those measures that are the most cost effective or required by local regulations. The team then identifies a number of added potential sustainability measures, usually more than are required to achieve the desired LEED™ goal, that might possibly be included in the project, but that require further review to determine their cost effectiveness and feasibility. LEED™ measures are also identified and eliminated that do not apply to the project and do not merit further discussion (e.g. Is the project site in a flood zone? If so, the project will not qualify for the LEED™ Site Selection credit, so this credit can be eliminated). From the list of measures used by each project in Table 1, it can be seen that different projects take widely different approaches to the LEED™ goal. This is reflective of the unique issues, constraints, and opportunities for each project.

A key finding is that unless the design team *integrates* the various sustainable design measures, the cost of achieving the desired level of LEED™ will be higher than otherwise. However, the required types and degrees of integration of "whole building" issues are foreign to standard design practice in the US, and require substantial attention to be successfully achieved.

2.3 Sustainable Design and Construction Implementation

Once the project team has determined which sustainability measures to include in the design, it falls to the design and construction teams to incorporate them into the building. It is not unusual for a project to lose some of its planned sustainability measures during this process. This may occur due to difficulties with product availability (e.g. a goal of using only wood grown in environmentally managed forests may be infeasible due to supply constraints) or inattention to specifications by construction trades (e.g. failure to use adhesives without Volatile Organic Compounds ("VOC's")). As a result, it is recommended that the project team provide a sustainability contingency buffer of "extra" LEED™ credits to account for these types of situations; otherwise, the project goal of achieving LEED™ certification may be jeopardized. It has been found that the threat of failure to achieve LEED™ certification is a crucial enforcement factor in achieving sustainability compliance. However, even with this leverage, compliance failures occur. It has been found that using a neutral third party, such as the LEED Consultant and/or the Commissioning Authority, to track the construction compliance issues, substantially improves success in this.

2.4 Documenting the Sustainability Design Measures

The final step in building a sustainable project and in achieving official LEED™ certification is documenting that the specified sustainability measures were actually built into the project. This documentation is often the most difficult part of the LEED™ sustainability process, as providing the required documentation paperwork is not a process with which most contractors are familiar. Even with the best of intentions, often the required documentation is not provided. Again, coordination among the members of the project team is of the utmost importance. If the actual installation of the sustainability measures cannot be properly documented, then the measure cannot be claimed as actually installed in the project. LEED™ is structured in such a way that it is very difficult, and not cost effective, to include sustainability measures that are design-based only. Construction compliance is a key issue, and documentation of how fully the specified sustainability process was followed is essential. Without this element of "proof of compliance", the LEED™ objectives of achieving an actual green building as constructed would not be achieved.

3. MARKET TRANSFORMATION

Every phase of the building design and construction process is affected by the application of the LEED™ system. This has both required and created a transformation in the marketplace, as follows:

- **Owners** have had to assess the value of the LEED™ rating, to determine the costs and benefits of having a LEED™ rating, and to understand the impact that it has on the building process. As this has occurred, many owners have set criteria for selection of Design Teams that require knowledge and experience with LEED™. This evolution is at an early stage, with government and non-profit organizations leading the way; only a few for-profit entities are yet applying LEED™, and that primarily for owner-occupied facilities.
- **Architects and Engineers** have had to learn the technical requirements of LEED™ and identify cost-effective ways of meeting and documenting those requirements, and to develop a revised design process which incorporates those requirements in an integrated fashion. This transformation is also at an early stage, although almost all A&E's have now been confronted with LEED™ as an issue.
- **Contractors** (both General and specific sub-trades) have had to learn how to accommodate the various construction-phase requirements of LEED™ in cost-effective ways and how to document compliance with LEED™. The need for orientation and training of the various members of the construction team in these issues has become clear. Given the relatively few projects that have yet been constructed using LEED™, the contracting community is the least far along in its adoption of and familiarity with LEED™.
- All three groups have had to become aware of the role of the **LEED Consultant** and the **Commissioning Authority** as project participants with unique perspectives on delivering project performance which is *measured* and *documented*.

4. ENVIRONMENTAL IMPACTS

The environmental impacts of applying LEED™ to the buildings are summarized in the graphs in Table 2. This table shows how eight of the ten buildings reduced the use of energy, water and landfill wastes, in almost all cases by a significant margin. The average reductions for these projects were: Energy usage 44%, Water Usage 41%, and Construction Waste 84%. These reductions are relative to the "base case" which is cited for each in Table 2.

5. CONCLUSIONS

Although LEED™ is still at an early stage of use, it is transforming the building design and construction market in environmentally significant ways.

- Environmental issues are now a focused discussion topic from the onset of project design.
- The use of the LEED™ rating metric as a project goal is very motivating and unifying: the Owner adopts the goal, and all Designers and Contractors become bound by it.
- LEED™ encourages a more integrated design and construction process among all the members of the project team, in order to achieve the LEED™ goal cost-effectively.
- LEED™ broadens the topics of discussion to many areas of environmental impact not previously considered at all in standard design and construction practice.
- Evaluation of the "base case" design, which is mandatory in determining what changes to the design and process are required to achieve the LEED™ rating, raises team technical understanding of key issues in a variety of environmental domains (beyond energy alone).
- The LEED™ requirements for commissioning and compliance documentation motivate the project team to continue its coordination to the end of the construction process.

6. REFERENCES

No published references. The data in Tables 1 and 2 utilize technical project data prepared by the authors' firm for the specific projects being discussed.

Exploration of a Generic Vs Regional Specific Indicator Framework for Green Building Assessment: including example from N. China

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1. INTRODUCTION

Green building assessment has been acknowledged as one of the most effective ways to encourage green building development. Different assessment tools and methods have been developed since 1990. From 1998, methods of establishing an international generic framework that can be used to compare the different assessments and to produce regionally specific styles have been explored internationally.

This paper explores possible ways to build a more comprehensive international generic indicator framework for green building assessment on the current existing tools and to customize it into a regionally specific model. Problems and constrains in such model's development and use in China are discussed.

2. INDICATOR FRAMEWORK

One of the basic functions of green building assessment is to benchmark the performance of buildings according to certain green indicator catalogues. In this sense, two components are essential in the assessment tool: (1) the "Indicator Framework" (including indicators, scales and benchmarks) established on different criteria and sub-criteria structure, (2) the "Methodology" (including rules and instructions) to use the "indicator framework" for the assessment. This paper concentrates on the first.

To maximize the flexibility of green building assessment at both international and regional levels, a generic assessment system with a comprehensive, flexible and dynamic "Indicator Framework" is necessary to be constructed. To establish the work on the existing research basis, three indicator structures in the existing assessment systems are reviewed. Compare, contrast and systematic integration methods are used to identify the union of the indicators from the three systems.

Table 1 shows the main indicator structures in Eco-Home (Rao, S., Yates, A., Brownhill, D., Howard, N. 2000), LEED (2.0) (U.S. Green Building Council, 2001) and GBTool (V1.51) (GBC International Framework Committee, 2001). The special indicators in each system, like Transport in Eco-home, Innovation in design process in LEED and Quality of service, Economics, Pre-operations management and Commuting transport in GBTool are underlined

Table 1 Green building indicator structures in the current existing systems

	Eco-Home (BREEAM)	LEED (2.0)	GBTool (V1.51)
Indicators	Issue categories 1. Energy **2. Transport** 3. Pollution 4. Materials 5. Water 6. Ecology and land use 7. Health and well-being	Project checklist **1. Sustainable site** 2. Water efficiency 3. Energy & atmosphere 4. Materials and resources 5. Indoor environmental quality **6. Innovation & design process** 7. Project total	Major issue area 1. Resource consumption 2. Loading 3. Indoor environmental quality **4. Quality of service** **5. Economics** **6. Pre-operations management** **7. Commuting transport.**

By analyzing their relevance from a broader sustainable perspective, the union of the indicators in the above three systems, together with more than one hundred quantitative and qualitative criteria is classified into five categories: Environment, Society, Human Being, Design and Plan, which forms the basis of the generic indicator framework (Table 2). Our object is to make it more comprehensive in content at the same time more concise in structure.

Table 2 Comprehensive indicator framework for the green building assessment

1. Environment 1.1 Resource consumption - Energy - Water - Land - Material - … 1.2 Environmental Loading - Air pollution - Solid wastes - Hazardous Wastes - Liquid Effluent - Electro-Magnetic Pollution - Impacts on Site and Adjacent Properties - …	**2. Human Being** 2.1 Indoor environmental quality - Air Quality - Ventilation - Thermal Comfort - Sunlight and Illumination - Noise control - Privacy and Access to Sunlight and Views - … 2.2 Quality of service - Flexibility and Adaptability - Controllability of Systems - Maintenance of Performance - …
3. Society 3.1 Economics - Economic Performance - … 3.2 Management - Construction Process Planning - Performance Tuning - Building Operations Planning - …	**4. Design** 4.1 Innovation in design process … **5. Plan** 5.1. Site plan 5.2. Transport plan 5.2. Site Development …

If continuing to abstract more special or common indicators from other assessment systems and/or research documents, and integrate them into the structure according to their relevance, a more comprehensive generic indicator framework could be established. The framework is open and dynamic in the way that it can always be renewed and enriched by adding up-to-date information from different researches in the world. Setting up of the generic benchmark and scales are left for implementation in the future when the green building practice and research reach more consistency in the world.

3. SPECIFIC INDICATOR FRAMEWORK

To assess green buildings in different regions, a regionally specific indicator framework should be customized from the international generic one and based on the special regional conditions and requirements. China is analyzed as an example in our exploration of such customization.

3.1 Classification of Regional Conditions in China

China has the largest population (about 22% of total population in the world), an extensive territory (6.5% of the world continental area) and very complex terrain, which present great differences in climate, culture and economic conditions from region to region.

The variety in different regions implies different requirements and focus of regional green building development, which are unlikely to be reflected and emphasized in a single assessment system. Bryan et al (2000) claimed that a suit of assessment tools with different functions could be used to satisfy the requirement of different clients. Inspired by this thought, this paper explores the possible ways of customizing a suit of regionally specific indicator frameworks from the same generic one to fit the variety of regional conditions.

To classify the regional conditions for green building assessment, following dimensions of variation are taken into account: 1) climate; 2) economy & technology; 3) population and nature resources.

3.1.1 Climate Variation Climate variation is the fundamental fact that influence and definite the regionally green building construction and assessment. The climate in China has very complex variations. Firstly, it varies in six zones from south to the north, which are equator, tropics, sub-tropics, temperate, and frigid zones. At the same time, its hydrological conditions vary in four areas from the east to the west, which are humid area, semi-humid area, semi-arid area, and drought area (http://www.ied.org.cn/China/china98.html, 2002, 4,4). Also, in terms of heating requirements, there are five areas from north and west to south and east, which are very cold area, cold area, hot in summer and cold in winter area, hot in summer and warm in winter area, and moderate area (National Heating Engineering Design Regulation for Residential Buildings, 1996).

To make it much more concisely, the above variations are classified into two areas in this research, which are the cold and arid area in the north and west China, and the warm to moderate and humid area in the south and east China.

3.1.2 Economy & technology These are two closely related and important dimensions that either support or restrict the green building development. In China, the general economy level and the technology development is higher and faster in the southeast than in the northwest area.

3.1.3 Population and nature resources These are the elements that require and emphasis the sustainable development. Population in China is distributed unevenly with more in the east and fewer in the west. Roughly, the nature resources (exclude the land resources for agriculture) are distributed more in the west and less in the east (except northeast).

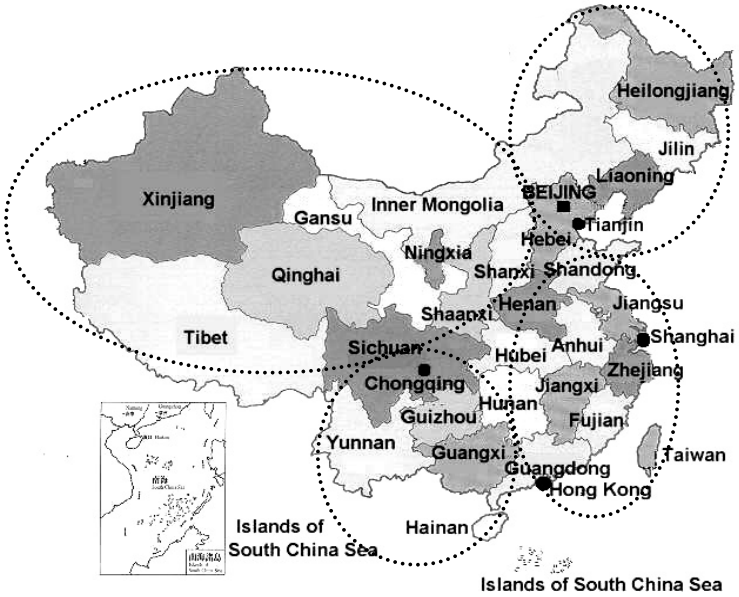

Figure 1 Map of China with circle lines to show the four sub-regions for green building assessment (The map of China is available in: http:// www.chinatour.com/map/a.htm)

According to their similarity and difference, the regional conditions in China can be roughly classified into at least four categories, which belong to four sub-regions (show in Figure 1 and Table 3). So, we suggest a suit of four regionally specific indicator frameworks be established or customized based on the generic one.

Table 3 Synthesis analysis and classification of the variation of conditions in China

	Northeast	Northwest Central and west	Southeast	South central
Climate	Very cold to cold	Very cold to cold & Arid	Worm & Humid	Warm to mediate & Humid
Level of Economy and Technology	Medium	Low	High	Medium
Population Density	High	Medium to Low	High	Medium to High
Natural Resources	More	More	Less	More

3.2 Investigation of Green Building Practice

Green building practice is the basis for green building assessment. To make it more feasible, the establishment or customisation of regional specific indicator framework for green building assessment should be initiated from the region(s) that have more active green building practices.

Such practices not only provide us possibilities and opportunities to collect regional green benchmark data for the indicator framework, but also demonstrate the level, extent and availability of regional green building technology as well as indicates the core of regional

environmental problems, which are important for setting up the regionally specific weighting system.

In China, the green building practices started from several big and economical developed cities, like Beijing, Shanghai and Guangzhou, and currently involved in residential, office and education building types.

We investigated a green office building in Beijing, together with other green oriented building designs in N. China during the end of 2001, and it is recognized that: all the five indicator categories in the generic indicator framework have been explored in the regional practices, while the emphasis of the green efforts have been placed on reducing the "resource consumption"(in the Environment category, Table 2) and on improving the "indoor environmental quality"(in Human Being category, Table 2). This emphasis in fact reflects a consistency with the focus of environmental problems being addressed most frequently in the professional publications as well as general public media in China.

Accordingly, we suggest that the customizing of a regionally specific indicator framework be initiated from establishing specific criteria and benchmark structure under "resource consumption" and "indoor environmental quality", since detailed data or references for these two subcategories are potentially more available in the current regional practices, documents and researches.

3.3 Problems and Further Research

While exploring the specific indicator framework in China, we find that the major problems and constrains exit especially in the relevant data collection and validation.

Firstly, the basic benchmark information for more than half of the criteria cannot be selected directly from the existing national or regional codes & regulations.

Secondly, when assessing the buildings from the green point of view, the data and information we need from the buildings are quite different compared to the traditional evaluation of a building. However, most of the designers are not acquainted with the differences, which cause some important green building assessment data to be ignored or not to be collected and recorded in time and in proper way.

Thirdly, green data collection and validation requires certain methodology, technology, equipment, experts and time conditions. Most of the factors have not been explored systematically in the region.

So, in the further research, a survey is designed and will be conducted to abstract basic benchmark data from the general practices in the region. The green building assessment data required from designers, especially the differences comparing with the traditional evaluation will be studied and listed in detail, and methods for the proper data collection and validation will also be explored systematically.

4. CONCLUSION

This paper explores the possible way to establish a generic vs. regional specific indicator framework for green building assessment. A more comprehensive generic indicator framework with more concise structure is established from three existing systems; a suit of four sub-regionally specific indicator frameworks is suggested to suit the variation of

conditions in the four classified areas; the emphasis, problems and constrains in the system customization is studies via investigation of green building cases in N. China.

The exploration will be continued, especially, the regional specific indicator framework for one of the four sub-regions (depending on the regional data availability) in China will be complemented from establishing specific criteria and benchmark structure under "resource consumption" and "indoor environmental quality"in the next stage.

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A comparative evaluation of building environmental assessment methods: suitability for the South African context

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1. INTRODUCTION

Building environmental assessment methods have emerged as a means to evaluate building performance across a broad range of environmental considerations. In addition, they are perceived as tools for promoting and contributing to sustainable construction. Due to the fact that they reconcile mandatory (i.e. by reference to standards) and market-driven approaches to promote sustainable construction practices, they are believed to be a potent agent of change in the specific context of the South African construction sector.

This paper reports on a research project carried out at the University of Cape Town that aimed to identify a building assessment method that would be the most suitable to assess sustainability of South African buildings. South Africa has previously adapted building environmental assessment methods that were designed in other countries. Thus, the research questioned whether building assessment tools originating from developed countries could satisfy the very different environmental focus and socio-economic needs of South Africa.

South Africa is a country of widening economic disparities, which remains the greatest single challenge in agreeing upon and achieving sustainable paths of development. This situation is also reflected in the nature of construction projects that are being undertaken in South Africa. These range from provision of low-cost housing, often based on the minimum acceptable standards, for which demand is still rising, to multi-million Rand developments such as the Cape Town International Convention Centre, which is expected to implement best construction practice. In addition, it may often seem that environmental considerations compete with socio-economic objectives in the hierarchy of priorities that drive the South African construction industry. Construction enterprises are required by legislation to implement affirmative policy that employs black and previously disadvantaged subcontractors. This requires additional financial resources to be designated to the training of such subcontractors. At the same time, excellence in environmental performance of construction projects might not be perceived as an important competitive advantage.

One cannot discuss the state of the South African environment and exclude the socio-economic reality of the country. As a country aspiring to a higher level of economic development, the greatest challenge facing South Africa is to improve the quality of human life for both present and future generations, without depleting natural capital and preserving

sustainability conditions (Burger, 2002). At the same time, South Africa is challenged by many problems experienced by developing countries in which rapid industralisation, population growth and urbanisation pose a great threat to the quality of the environment.

The construction industry has a responsibility to direct its development on a sustainable path using all available instruments, due to its significant contribution to national socio-economic development and potentially significant environmental impact.

2. DEFINING SUSTAINABILITY OF SOUTH AFRICAN BUILT ENVIRONMENT

It is difficult to define a sustainable building, and even more difficult to define sustainable built environment. This is because sustainability can only be defined by its objectives and not by the end-points. Thus, it becomes equally difficult to list characteristics of a building assessment method that would be capable of adequately assessing a building's sustainability.

In order to choose a building assessment tool that would respond to the unique requirements of the South African built environment, it is necessary to understand all factors that make it sustainable. This task was aided by the review of four sustainability frameworks, namely:

- *"Caring for the Earth"* – a guide to Sustainable Living in South Africa (Yeld, 1997);
- *"The Natural Step"* framework to sustainability [www.naturalstep.org];
- *"The Four Pillars"* of Sustainable Construction (Hill and Bowen, 1997); and
- *"The Bellagio Principles"* of sustainability assessment (Hardi and Zdan, 1997).

These frameworks provided principles that should be incorporated in building assessment methods and guided formulation of the parameters for the comparative evaluation of selected building environmental assessment methods.

2.1 Synthesis of frameworks

The four sustainability frameworks reveal a large degree of analogy, as many principles of sustainability recurred during the analysis. Yet, by providing distinct angles to the discussion of sustainability issues, the frameworks seem to complement each other.

Several key factors dealing with technical approaches, human dimension, strategic approaches and broader sustainability issues emerged from the analysis. With regard to the technical aspects of building developments, it was concluded that building environmental assessment should be capable of evaluating all building types and promote the use of environmentally-friendly technologies. Further, building assessment should promote designs and initiatives that encourage resource-efficiency and waste reduction during all phases of a building's lifecycle.

Although buildings are often evaluated only from the technical perspective, all four frameworks emphasise the importance of the human dimension in achieving sustainability. Therefore, accounting for the human aspects should be reflected in the structure of a building assessment method and the assessment processes itself. The building assessment methods should promote 'humanised developments' that improve the quality of life but also allow all role players to be involved in the decision-making process. Moreover, it is important to recognise the educational role of building assessment methods aimed at changing personal attitudes and practices that prevent society from pursuing sustainable paths of development.

In addition to the above-mentioned factors, a strategic approach to building assessment is crucial to provide a broader perspective on how the construction industry can become more environmentally sustainable. Building assessment tools need to use a systems approach that

recognises the connectivity between the built and natural environments, and thus incorporate a holistic perspective in the assessment. The assessment tools should address global environmental issues as well as recognise indirect and cumulative impacts that buildings have at the regional and local scales. It is important that building assessment methods adopt a time horizon that captures both ecosystem and human time scales, responding to the needs of long and short-term decision-making. Moreover, they should examine both positive and negative consequences of human activity to facilitate weighing up of environmental costs and benefits associated with building developments.

3. COMPARATIVE EVALUATION OF BUILDING ASSESSMENT METHODS

The first step in the evaluation of selected building assessment tools was to develop a set of parameters whereby the building assessment tools in question could be objectively compared. The parameters were ranked in order of importance, as prioritising parameters in terms of their significance allowed for a more accurate comparison of building environmental assessment tools. In addition, a three-point scale was chosen for the purpose of rating individual parameters. This type of qualitative scoring gave a fair reflection of the strengths and weaknesses of the various methods to suit South African requirements. Therefore, parameters were rated either as '*good*', '*satisfactory*' or '*poor*'.

3.1 Parameters for evaluation

The parameters that were selected for comparing selected building environmental assessment methods are the key requirements for such tools. They indicate characteristics and crucial aspects of assessment methods necessary for a more adequate evaluation of buildings environmental sustainability in South Africa. The parameters, developed using the four sustainability frameworks, outlined above, are listed in order of their significance:

- *Comprehensiveness;*
- *Effectiveness;*
- *Adaptability;*
- *Flexibility;*
- *Practicality and Cost;*
- *Accessibility;*
- *Integration;* and
- *Consistency*.

The most important characteristics of each building assessment method are their comprehensiveness and the degree of their effectiveness. The evaluation of comprehensiveness of assessment included reference to global, regional and local issues of building sustainability and key building performance areas (i.e. energy, water, materials, environmental loadings, health and safety, and building context). In addition, the extent to which the building assessment methods covered the entire building lifecycle was examined.

The effectiveness of building assessment tools was evaluated by examination of their potential applications. This ranged from guideline systems, by providing ways to integrate technical and environmental sustainability aspects into planning and design, to labelling tools, which demonstrate improvements in the environmental performance of buildings. Furthermore, the tools were assessed with respect to their contribution to the education of all stakeholders that could facilitate changes in their attitudes and practice.

Further, the comparative evaluation focused on the ability of a building assessment tool to acknowledge national, regional and local conditions and cultural values – embraced by the adaptability parameter. At the same time, the tools were examined with regard to their

capability to compare building performance based on standards and thresholds in accordance with South African best practice, market trends and regulations. Adaptability is closely associated with integration and refers to the linkages to other established procedures (e.g. Life Cycle Assessment, Environmental Impact Assessment or Environmental Management Systems) and established standards (International Organisation for Standardisation, South African Bureau of Standards). Building assessment methods should be strengthened by linking to established standards resulting in a streamlining of building assessment processes. The parameter of integration also requires implementation of a systems approach to building assessment.

Moreover, the assessment methods were evaluated to determine whether they permit different levels of assessment, cater for regionally specific environmental criteria, and weight them appropriately. The methods should also be flexible enough to allow the level of assessment to be adjusted according to the amount and quality of available information, as well as the complexity of the building system.

The building assessment tools were also evaluated with regard to their practicality (including user-friendliness) and cost. Ideally, building assessment methods should be comprehensive enough to satisfy purpose without being overly expensive or impractical to use. These aspects are linked to another important issue, namely communication of information and results of the assessment, which impact on the user-friendliness and effectiveness of the building assessment methods. The criterion of accessibility required evaluation of the manner in which assessment information, as well as explanation of the overall building score, is communicated to all role-players.

Other factors that were taken into account during the evaluation included the repeatability of the assessment assuming the same benchmarks and level of standardisation in the assessment framework, and consistency between the levels of assessment. By comparing selected building environmental assessment methods using the above parameters, it was possible to identify the most suitable building assessment tool for South African built environment.

3.2 Discussion of findings

The function of the evaluation was to aid in the development of a method that could serve as a tool to measure the biophysical dimension of sustainability in South African buildings and construction in general. The assessment tools selected for the purposes of the comparative evaluation included Leadership in Energy and Environmental Design (LEED), the Building Research Establishment Environmental Assessment Method (BREEAM), Green Building Tool (GBTool) and the Sustainable Building Assessment Tool (SBAT). The results of the evaluation are presented in Table 1. Assessments of individual characteristics, although subjective in nature, were made as objectively as circumstances allowed.

Table 1 Comparative Evaluation of Selected Building Assessment Methods

Parameter	LEED	BREEAM	GBTool	SBAT
Comprehensiveness	Good	Satisfactory	Good	Satisfactory
Effectiveness	Good	Satisfactory	Satisfactory	Satisfactory
Adaptability	Poor	Poor	Good	Satisfactory
Flexibility	Poor	Good	Good	Good
Practicality and Cost	Satisfactory	Satisfactory	Poor	Satisfactory
Accessibility	Poor	Satisfactory	Good	Satisfactory
Integration	Good	Satisfactory	Good	Satisfactory
Consistency	Good	Good	Good	Satisfactory

The LEED and BREEAM methods were developed to suit the context of developed countries and thus lack the adaptability necessary to apply them in other countries. They emerged as a response to the specific needs of buildings and environments in their respective countries of origin. Therefore they are insufficient in addressing issues that are relevant to developing countries (e.g. socio-economic aspects related to building environmental impacts), and are based on norms that are not applicable in South Africa. Adapting these methods to South African condition would require redesigning their assessment frameworks.

In addition, both BREEAM and LEED do not acknowledge the variations in regional and local conditions. While LEED's accessibility is compromised by a failure to provide an adequate breakdown of the results, and is inflexible, it remains a comprehensive assessment tool which covers building performance areas in detail and uses a life-cycle approach. On the other hand, BREEAM does not provide for an adequate assessment of the biophysical dimension of sustainability in South African buildings (e.g. not enough emphasis is placed on water conservation issues and biodiversity protection). Its main disadvantage is an insufficient integration of life cycle approaches in the assessment. However, flexibility and consistency are strengths of BREEAM, while other areas of the evaluation were covered in a satisfactory manner. BREEAM comprises customised versions of the assessment framework for different building types and assessment options.

GBTool would not suffice as a building assessment tool for South African conditions, as like LEED and BREEAM, it does not incorporate socio-economic and cultural issues of building developments. However, it certainly addresses biophysical environmental issues in the most comprehensible and dynamic manner of all the evaluated methods. GBTool addresses all building performance areas and all stages of the building lifecycle. Moreover, it applies a systems approach to building assessment by measuring system inputs and outputs as well as its context (i.e. accounting for urban context). Thus, GBTool can be easily adapted to different built environments.

The customisation of benchmarks and the weighting system provides opportunities to make GBTool suitable and highly relevant to the South African context. In addition, the software application facilitates data handling and allows for improved accessibility. On the other hand, the practical (i.e. complex and time-consuming assessment procedure) and cost constraints of GBTool are a result of its detailed assessment procedure. Experience shows that many South African buildings lack the environmental information required to complete the assessment. Although GBTool allows for different levels of assessment detail, depending on the amount and quality of available information, it is not practical or cost-effective.

In contrast to the other methods, SBAT has been designed for South Africa buildings but in striving for simplicity, it compromises in terms of comprehensiveness in covering the biophysical building issues. On a positive note, SBAT accounts for issues that are significant in South African context (e.g. local environmental issues and participation). By involving interested and affected parties in the development of sustainability performance targets that form the basis of SBAT, the method caters for specific regional conditions and cultural values. However, this aspect makes it difficult to compare the performance of similar buildings. Because benchmarks and sustainability targets are different for each assessed building development, performance measurements are not standardized. Thus, this method does not indicate how individual buildings are contributing to the overall sustainability of the construction sector.

4. CONCLUSIONS AND RECOMMENDATIONS

The focus of this study was on the biophysical aspects of building environmental performance. Nevertheless, it is acknowledged that socio-economic, cultural, technical and process-orientated dimensions of environmental sustainability are inextricably linked to biophysical issues and cannot be ignored.

The research showed that the assessment of South African buildings demands a different approach to that used by developed countries. Such an approach should include socio-economic and cultural aspects of sustainability, not just biophysical environmental concerns. Existing building environmental tools emphasise efficiency, but are yet to properly include broader sustainability aspects. A building assessment tool that evaluates buildings purely on the basis of their environmental efficiency is unlikely to create significant positive change in South African building developments.

None of the evaluated building assessment methods proved to be an ideal tool to measure the biophysical sustainability in South African buildings. They all require a certain amount of revision and improvements. In the case of BREEAM and LEED, the most essential changes that would be required for their application in South Africa include modification of benchmarks and development of an appropriate weighting system. These tools rely on standards, and promote environmental building technologies that are not always available in South Africa. Likewise, customisation of GBTool to the South African context also requires development of benchmarks and a weighting system.

SBAT offers a new approach to the assessment of building sustainability, where social and economic aspects are as equally important as environmental performance issues. Yet, in order to be more effective, a more in-depth assessment of environmental issues is required. Thus, SBAT should adopt the best environmental aspects of other assessment methods, whilst building on its socio-economic strengths.

It is clear that, while existing building environmental assessment methods have managed to improve the environmental performance of buildings to a degree, there is a need for a uniquely South African system.

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A New Sustainable Approach
Challenge of Subtropical Region

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1. MYTH OF WESTERN DEVELOPED MODE

1.1 Industrialization and Urbanization

As recently as in the 1970s, the resources of our planet were generally considered to be in abundant supply and sustainable development was taken for granted. Among advanced Western countries, a common pattern evolved in the way these resources were exploited (Wallerstein, 1976; Corbridge, 1986), specifically, through industrialization and urbanization. In each of these countries, industrialization took on unique characteristics as international trade encouraged specialization and differences based on comparative advantage. By comparison, urbanization resulted in nearly identical urban cultures born in the image of the industrial goods that flowed through them(Hall, 1998).

1.2 Similarly Urbanized Civilization

Moreover, the successful developmental experience of the advanced nations was emulated in the lesser-developed world, which envied the West for the convenience and prosperity that industrialization and urbanization allowed. These countries hoped that through industrialization, the international division of labor, and trade (Frobel & Kreye, 1980; Doreen Massey, 1995), they could also enjoy the things of their more advanced counterparts.(Miller, 1987) Under this market mechanism, their cities became virtual facsimiles of those in the Western world, and their values and cultural forms became homogenized as well. (Featherstone, 1990) Throughout it all, few paused to consider the incongruity that such imitation produced among the architecture, the local climate, and geography.

1.3 Energy Crisis

Only after the energy crisis have people awoken to the stereotyping influence of international trade and western culture on the principle buildings of the urbanized world. They have also become acutely aware of the shortcomings of these structures in their ability to accommodate local conditions. Architecture thus conceived has not only failed effectively to address housing problems, it has also produced a gross waste of natural resources and environmental harm, including the waste of energy and misuse of building materials.

1.4 Subtropical Region's Theses

These problems will be explored in-depth in three illuminating studies to be delivered shortly at the start of this session. They include a report by Japanese scholar Professor Kazuo Iwamura on the problem of providing comfortable housing during the hot and humid summers in Japan's subtropical regions; a study by Singapore's Professor William Lim on the intimate relationship between the development of Western high-technology and social, environmental and spatial equality in Singapore; and a paper by Professors Wan-Ki Chow and

Wing-Yan Hung of Hong Kong analyzing the problem of energy consumption in hot environments. I trust that these presentations will further confirm the evident truth that western methods are not optimized for regions outside the Temperate and Frigid Zones, and that their adoption to subtropical regions has led to a waste and misuse of natural resources. The same is true in my native-Taiwan, whose relatively closed-in circumstances and dense population have further contributed to the problem of environmental degradation.

2.THE BELIEF OF ARCHILIFE RESEARCH FOUNDATION

This is what motivated Mr. Chun-Shin Lin to found the Archilife Research Foundation and to devote his full energies to finding a sustainable development model for Taiwan. After 23 years, we finally have results to show from these efforts. Moreover, we can now say with certainty that it is a mistake to blindly follow societies with geographic and climatic conditions at odds with our own. We have become aware of the need to engage in a dialogue specific to our own geographies and climates. And we realize the importance of marshalling our knowledge and technology to the cause of redefining our buildings and settlement modes and drafting the best possible blueprint for reducing the burden on our environment and our strained energy resources. At the same time, we believe that architecture also serves to insulate us physically, to protect us from the elements, and to provide the conditions of comfort and health basic to life. Buildings provide a buffer between their occupants and their local environment and climate, which means that their structures and facilities need to be able to respond to these local conditions. This of course requires the use of natural resources and energy, the accumulation of which inevitably impacts national resource and energy policies. This in turn affects domestic demand for industrial and imported goods, which influences the makeup of a country's export industries and trade, which ultimately determines its areas of industrialization and the demands on natural resources. The efficiency and cyclical usage in these areas and demands are the key determinants of a nation's sustainability.

3. OUR ACTIONS

3.1 Specifications of Next Generation Settlements

Based on this idea, we set out in 1979, the year of our founding, to establish a knowledge bank, provide research scholarships, recruit high-level researchers, and address issues in which research has been traditionally lacking. After the completion of this preparatory work, the foundation embarked in 1987 on a 10-year study of "Specifications of Next Generation Settlements" (SONGS) to identify local habitation standards for Taiwan. In 1996, we formed the "SONGS Task Force" to compile 155 foundation-supported dissertations and 26 group commissioned studies prepared over a 10-year period. Some 34 seminars were held in the course of this project, which resulted in the "1999 SONGS Report". The task force also issued "The Declaration of SONGS", in which 20 indices were offered as the basis for dialogue with our environment (Table 1). Moreover, in 1990, 175 outstanding keepers began to compile index books to integrate the resources of the knowledge bank and broaden our research base. This knowledge has made us increasingly aware that we should learn from the symbiotic relationships prevalent in the biological world as we seek to reconcile human development and environmental conservation.

Table 1 The proposed specifications of next generation settlements.

1. Spatial design that complies individual needs with provisions for the family's life cycle and socio-economic changes.
2. Select safe locations and be able to prevent as well as be prepared for disasters.
3. Provide adequate shared public space and facilities.
4. Layout and use space precisely and efficiently.
5. Create barrier-free environments for family living.
6. Adopt ductile design in structure; furnish isolation or energy dissipation systems, so buildings can be repaired even suffering from strong shaking.
7. Precisely design construction and building materials according to principles of modularization and flexibility.
8. Plan to recycle and reuse building parts in different stages of the life cycle of the building.
9. Adopt the construction method of on-site assembling of prefabricated building elements.
10. Control interior environment by natural means; use mechanical facilities only when necessary.
11. Use sound insulation and absorption to reduce noises.
12. Use sun-shading and sun-reflecting devices; make good use of natural lighting.
13. Use natural air convection to control ventilation, temperature, and humidity.
14. Install air purification facilities.
15. Install water purification, quality monitoring, and recycle systems.
16. Provide multiple energy conversion systems.
17. Create intelligent living environment equipped with integrated security monitoring, energy consumption and facility management systems.
18. Install equipment that provides secure and swift information access and retrieval functions.
19. Provide maintenance access openings and mark ducts, pipelines and conduits for easy maintenance and scheduled replacements.
20. Install facilities to prevent bio-invasions.

Reference: The Declaration of SONGS, 1999 SONGS Report, Archilife Research Foundation.

3.2 Symbiotic Living

Therefore, from 1996, we have gradually expanded from our early work centered on sustainable buildings to encompass the external environment of these buildings (Figure 1). The purpose of this effort is to establish a high-efficiency and symbiotic circulatory system that can mitigate the burden of human activities on our environment. We call this strategy “symbiosis”, in the biological sense, by which building structures are designed to encourage a closer integration of our habitats and the food we eat, especially green vegetables and fruit. In this way our output can become the input for plants, and the output of plants becomes our input. We hope that as this cycle becomes more efficient, it will alleviate the burden of human activities on our surroundings. We also hope that the transpiration of greenery will reduce the unusually hot temperature of building facades in Taiwan. In terms of structures, we have borrowed from the wisdom of subtropical aboriginals and the ancient Romans in their methods of controlling heat and humidity. We designed a laboratory to first verify structural feasibility and determine building properties. These initial results were then applied to modular buildings for more integrated experiments. The purpose of these studies was to adopt the symbiotic relationships familiar in the biological world as a new basis for our dialogue with our environment.

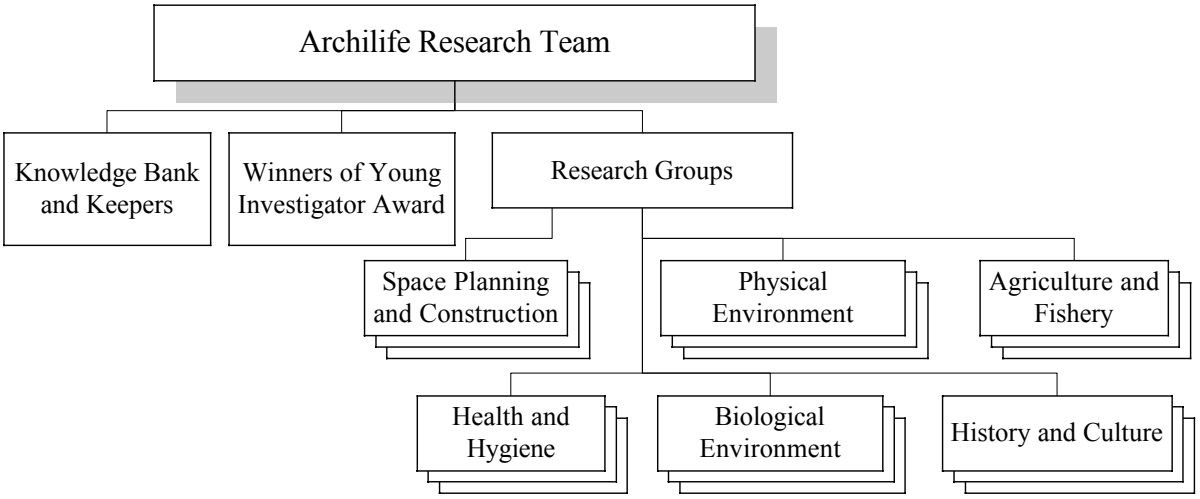

Figure 1 Archilife Research Team.

4. TAIWAN'S THESES

After this speech, we will present four reports from the various research groups. Professor Chao-Lee Kao of the History and Culture Group will lecture on the topic "Bunun Dwelling: A Study on the Tectonic Culture of the Aborigines in Taiwan"; Professors Chao-Ching Yu and Ching-Yuan Lin of the Space Planning and Construction Group will speak on "The Application of a Full-Scale Experimental Model in the Climate Chamber in Taiwan"; Professor Che-Ming Chiang of the Physical Environment Group will deliver a paper on "New Climate-Oriented Designing and Controlling Strategy for Sustainable Building in Subtropical Region"; and Professor Ching-Hua Su of the Biological Environment Group ,Professor Hong-Mo Lee of the Health and Hygiene Group, and Professor Cheng-Yung Cheng of the Agriculture and Fishery Group will jointly speak on the issue of "Integration of a Symbiotic Living Construction: A High Efficiency Recycling System". I am sure that these presentations will help you to better understand the gist of our work. Although the tangible achievements of these efforts could not be completed in time for this conference, I can guarantee that we will have results, whether successful or not, to share with you all at SB2004.

5. CONCLUSION

In closing, I would like to summarize three main conclusions:

1. Architecture should have the capacity to respond to its local environment and climate, while also providing for the comfort and health of its inhabitants.
2. Sustainability is a complex subject that needs to be addressed cooperatively on many different levels and from many different angles if we are to come up with comprehensive solutions. Moreover, real dialogue with our environment will require continued experimentation, refinement, implementation and feedback.
3. "Symbiosis" is a kind of micro-scale symbiotic model based on nature. It requires that people establish an intimate symbiotic relationship with the biological world, and particularly with the vegetables and fruit they eat, in order to minimize their impact on nature and ensure environmental sustainability.

Based on these conclusions, I hope that Taiwan and other subtropical regions can begin on the micro scale and work towards the macro level, from individual points to connected wholes, from the formation of basic living settlements to the national level. We hope, moreover, that by changing the environmental, resource, and energy strategies of our countries we can bring about change in our overall living communities and ecological environment. Perhaps this can also serve as a reference for advanced Western countries, and bring us all one-step closer to a sustainable future.

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Bunun Dwelling:
A Study on the Tectonic Culture of the Aborigines in Taiwan

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1. ABORIBINAL VILLAGES IN TAIWAN

1.1. Geographical Distribution

More than two-thirds of central Taiwan is mountainous. The majority of the inhabitants of this region are Austronesian aborigines, including plains and highland tribes. They currently number about 330,000 people, or 2% of Taiwan's total population, yet they occupy 44.3% of the total area of the island. The highland aboriginals comprise 10 major tribes, including the Atayal, Saisiyat, Bunun, Tsou, Paiwan, Rukai, Ami, Puyama, and Thao, as well as the Tao people of Orchid Island. They live predominately in mountainous areas . Over the last century of modernization, these tribes have undergone considerable change, yet they have still preserved their unique customs and lifestyle. Their symbiotic relationship with nature, in particular, is worthy of our study.

1.2 Aboriginal Architecture

Despite the limited size of Taiwan, a rolling coverage of mountains and the embracing sea have incubated a rich and varied natural ecology on the island. This unique environment has also fostered the rise various tectonic cultures among indigenous peoples.

While semantic anthropologists have identified several unique linguistic traits among the languages of the aboriginal tribes of Taiwan, differences among these tribes in terms of built forms are far more difficult to distinguish. From field studies we know that the built forms of different but geographically proximate tribes gradually converged due to environmental limitations. We also know that the dwellings of the same tribe vary markedly both in construction methods and built form across different geographical regions.

The Bunun are the most representative of Taiwan's highland aboriginal peoples. They are also the last to have been impacted by modernization, such that the traditional wisdom embodied in their tectonic culture has remained relatively more intact than in other tribes. This paper has therefore selected the Bunun as a case study in tectonic culture and its relationship to the natural environment.

2.BUNUN VILLAGE

2.1 The Villages and Their Environment

The Bunun are typical of Taiwan's highland aborigines. They live primarily in the areas of Yushan and the Central Range at elevations ranging from 500 to 3,000 meters above sea-level. The majority are concentrated in rocky elevations of between 1,000 and 1,500 meters, making them the highest dwelling tribe in Taiwan. This area has an average annual

precipitation of 2,500 millimeters, and there are wide fluctuations in seasonal rainfall. Severe erosion caused by rapidly river flow has carved out a unique natural environment, which is characterized by a close weave of first-growth alpine forests, tablelands, gorges and hills. Millet is the staple of the traditional Bunun diet, while yams and taro serve as supplementary foods. The main sources of meat are goat, boar, deer and wild birds.

The land of a traditional Bunun tribal unit is divided into living, farming and hunting areas. The living area is the basic unit of the village and usually consists of a main dwelling and several outbuildings, such as a chicken coop, pigsty and defensive fortifications, the use and ownership of which belong to a single clan. Ownership of farmland is also clan-based. Since the Bunun adopt a slash-and-burn method of agriculture, the arable land of a clan is often divided over several separate areas and cultivated on a rotational basis. A small work shed is frequently erected on land remote from the main house. Hunting grounds are owned by patrilineally defined clans, though they are often used collectively by the village. If a clan wishes to hunt on the grounds of another, it must first get the consent of the owner and present part of the catch to the consenting clan. In some villages, it is customary to build a small shrine on the hunting grounds for offering sacrifices.

Traditionally, most Bunun tribes live in scattered communities. They generally build their homes on steep terrain to defend against enemies, and they are careful to maintain a certain distance between the villages and rivers. There is no specific pattern to the distribution of homes in the village, though most are separated. Compounds housing three to four families are sometimes found, though the majority of these dwellings house a single clan.

Since there is no clear social stratification in Bunun tribes, every clan has equal status in principle. The chieftains and military leaders are not hereditarily determined, so there are no obvious power centers in the tribal space.

The household itself forms an independent economic unit, so there is no need for communal production across clans. For this reason, there is a considerable distance between individual households. Bunun dwellings are located on crest lines to provide the best defensive vantage. Enlargements to the home or the addition of new clan dwellings extend laterally, such that each clan family occupies a certain elevation and different clans are vertically separated.

The Bunun emphasis on the development of vertical contours is evident in the language, which contains comparatively more words for describing vertical contours in spatial arrangement than for describing collateral contours.

2.2 Social Milieu

While Bunun life is based on the household, there are two levels of social organization above the family. One is the consanguine clan, under which the codes of religion, marriage and law operate. The other is a geographical organization, under which hunting, warfare, and daily matters of the tribe are determined by a council of elders. The elders are usually chosen from among the heads of clans or people of unusual talent, such as a skillful hunter. The Bunun have no hereditary aristocratic class or chieftain system. If exigent circumstances require a leader, one will be selected by the tribal elders.

The most important communal activity among the Bunun is the "*Malah-tagia*". This ceremony, involving the target shooting of the ear of a deer, serves mainly as a supplication for a successful hunt. It is the biggest ceremonial assembly of tribal members during the entire

year, bringing together all of the males of the tribe, and therefore has social and political dimensions as well. It can serve, moreover, as an occasion for determining tribal territorial boundaries (Huang Ying-Ku, 1995).

3. BUNUN HOUSE

3.1 Family Structure

Bunun households are typically large. “The biggest has 60 to 70 members, and some bring together as many as 80 people under one roof. They work long hours and a three-year supply of grain can be stored at home” (Mori Ushinosuke, 1913).

The Bunun traditionally live in patrilineally determined extended families with the clan as the most basic unit. With the exception of daughters, who marry out of the clan, natalocal dwelling predominated. This naturally encourages the rise of large households bringing together several generations of nuclear families. In short, all agnatic members of the family live together in one big house and communally share the stove, millet granary, and available work.

In their effort to expand their families, the Bunun have also formed a special cohabitant system by which a non-blood relative can be inducted into the family (Okada Ken, 1938). The bigger the household, the greater its productive power and prosperity. The upper limit on household size is circumscribed only by the amount of surrounding arable land. Once this is exhausted, the family needs to divide and seek new farming land elsewhere. Household affairs are decided in principle by the head of the family (the most senior and high-ranking male), but if his abilities are lacking or differences of opinion persist, a new leader may be chosen or the family may divide.

3.2 House Form and Building Construction

The principle traditional structure in Bunun villages is the home. Occasionally there will be an assembly hall for male members of the tribe, though these structures are also built in a style similar to the home. Bunun dwellings vary in style between the northern and southern tribes, reflecting the availability of local materials, though their basic layout is roughly the same. Most Bunun homes have a raised sleeping area, kitchen, granary and multi-purpose space. The sleeping and cooking areas occupy the front half of the house, and the granary and other storage spaces are in the rear half .

Japanese scholars Toril Ryuzo and Sayama Yukichi have identified two basic types of Bunun building types, including stone slab and wood-plank homes. Chichiwa Suketaro has also distinguished two basic types of Bunun dwelling, both based on the same basic plan consisting of a single rectangular room, and gable roof. The two styles differ only in choice of building materials. Among tribes of the Nantou and Hualien areas, the “cave type” prevails, in which the outer walls and roof are built from stone slate; while tribes living near Taitung and Kaohsiung adopt a “platform type” with wooden outer walls and a wood shingle or thatch roof , (Chichiwa Suketaro, 1977). This difference is probably due in part to adaptations to accommodate local conditions and locally available materials. Tribes living in areas with an abundance of rock slate naturally developed skill in using this material, while communities in areas lacking slate turned instinctively to wood and grass. Defensive considerations have certainly also played a hand in the differences between the two housing styles. The rock slate “cave type” built forms are much better defended than their “platform type” with wood and

thatch counterparts. The former style also reflects the uneasy relations that existed between the Bunun in Nantou and Hualien and their Atayal neighbors.

The general process followed by the Bunun when building their homes is as follows: 1) divination of the land; 2) clearing the land of vegetation and collecting materials; 3) leveling the ground; 4) erecting the columns; 5) erecting the beams; 6) laying the roof; 7) building the walls; 8) building the granary; 9) finishing the cooking area; 10) finishing the sleeping quarters; 11) setting the wooden doors; 12) laying the slate foundation; and 13) holding a ceremonial banquet upon completion of the work.

Since the Bunun first construct the framing of the house, it is clear that the outer walls are not load bearing and could thus be made of slate or wood without interfering with the wood roof truss system. Consequently, both interior dividers and outer walls could be easily moved, facilitating expansions to accommodate growing families. The placement of the principle supporting structures on the short gable ends of the house also made lateral expansions easier, since one only had to add new roof trusses. These continual extensions resulted in structures that differed only slightly in terms of depth but had inordinately wide facades.

3.3 Ritual and Symbolism

The Bunun people have several taboos. For example, when hunting or travelling, the flight direction of a bird called the “has-has” is used to determine the auspiciousness of the venture and predict the weather or changes of events.

In contrast to hunting, which is a collective activity involving the whole village, millet farming is the main family-based activity among the Bunun. This is true as well of the rituals carried out during the various stages of the farming cycle, including the ground breaking, the start and completion of the sowing, weeding, the driving off of birds, harvest and storage of the grain. In addition to its storage function, the household millet granary also has important symbolic meaning to the family. Firstly, a granary with more than a year's supply of millet signifies that a family is truly independent and does not depend on outside support. The granary is also off-limits to outsiders, and to be able to enter this room signifies that one has been accepted into the family. Brides and other new family members are required to spend some time in the granary as part of a cleansing ceremony before they can formally join the clan (Chiu C.C., 1966: 67).

The Bunun, like the Tsou and Paiwan, traditionally buried their dead inside the home in the belief that the spirits of the deceased would protect and aid the family. Consequently, only those of strength and goodness were afforded the privilege of an indoor burial. The old and weak were interred in the yard and the cruel were buried far away from the village (Sayama Yukichi, 1919). Males were buried facing east and females facing west. After the Japanese colonial period, indoor interment was banned and Bunun burial grounds moved thereafter to a place below and downstream from the village.

Bunun taboos and myths are a dialogue between man and nature—the product of collective participation and the revision of history. In primitive societies, taboo and myth are inseparable from nature. Man coexists with the rest of creation. Through taboo and myth, the Bunun have preserved the life experience of their ancestors across generations and revealed to us an order for sustainable development.

4. CONCLUSION

As we confront the environmental crisis produced by urban architecture in the industrialized world during the twentieth century, the tectonic culture of the Bunun aboriginals offers an alternative worthy of our consideration. In Bunun buildings, objects, dress, taboos and myths, one can identify an intimate relation to nature. The materials used by the tribe come from nature, and to nature they are returned. Through this mode of sustainable development, their artifacts incorporate the relation between man and nature. The Bunun are therefore an important gene in helping us to understand the nature as a tectonic culture.

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New Climate-Oriented Designing and Controlling Strategy for Sustainable Building in Subtropical Region

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1. INTRODUCTION

Since the year 1998 the first Green Building Challenge was held in Vancouver, the trend of sustainable or green building issues became the future step for the architects and the building developers to follow up. Literature review shows that many indicators have been used in sustainable building assessment system, including assessment of environmental impacts, surface environment of building, energy-efficient and reuse, water recycle, materials selection, efficient use of nature resources, indoor environmental health indicators, and etc.

Taiwan, the Formosa, located in subtropical area in East Asia, also developed the new concept of the future building. Year 2001 was an important turning point for Taiwan because the new government declared and proposed a "Green silicon island" blueprint for future development. The "Green silicon island" is a strategic plan to redevelop Taiwan into a country with unique green life, rich eco-diversity, and sustainable economic development. The development of sustainable building to change fundamentally living environments in Taiwan is therefore crucial to implement this blueprint.

Our study is therefore aimed to develop an assessment system by integrating subtropical climatic factors, geographic characteristics, ecological consideration, energy-efficiency and healthy living consideration to design a sustainable building reflecting the unique concerns of subtropical region.

2. NEW CONCEPTS OF SUSTAINABLE BUILDING IN TAIWAN

Since 1994, the Archilife Research Foundation began the research stage of symbiosis buildings. The research group includes Physical-Environment, Space Planning and Construction, Biological-Environment, Agriculture and Fishery, Health and Hygiene, and History and culture. The long-term research developed the new concepts of sustainable building in Taiwan.

2.1 Climate and Geography Dependent Design

From a geographic perspective, Taiwan presents a great level of variation. For example, the

highest mountain is 3,998 meter high from the sea level, and plain stands for 20% area of the entire island. The central mountain chain strings up from the north to the south of Taiwan.

In terms of climatic variation, the direction of monsoon is North-East direction in winter and South-West in summer. The average temperature in summer is 28.5 degree in Celsius with frequent typhoons, and 14.8 degree in Celsius with Mainland frigid air mass. The average relative humidity level is 83%. The climate is very different between the north and south, the east and west parts. The geographic difference results in the great diversity of microclimate in this small island. Figure 1 is the yearly variation of climate observed by the weather station we set up in Fulong of northern Taiwan that is quite different from the other parts of Taiwan. The yearly variation is approximately following to the 24 solar terms in old Chinese calendar.

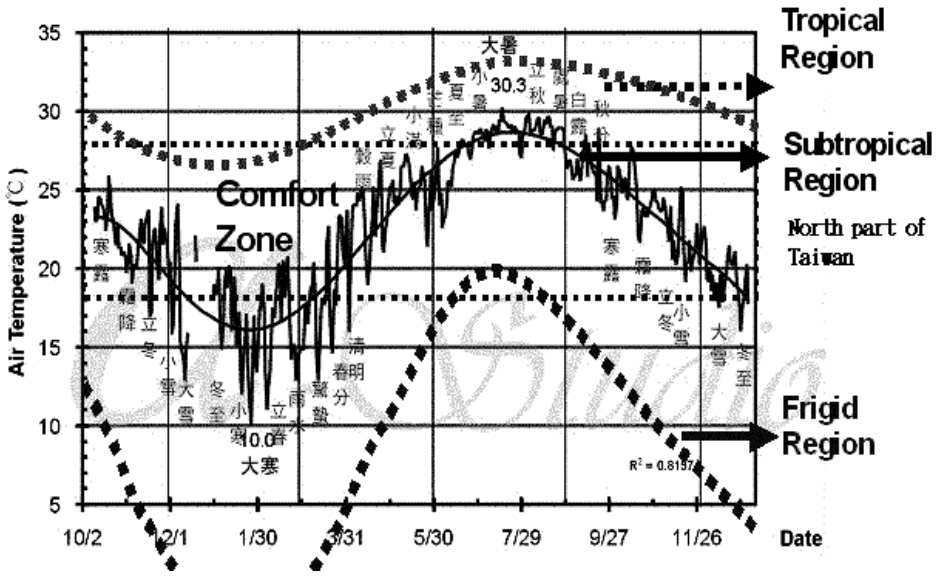


Figure 1 Yearly variation of climate observed by weather station in Fulong.

The geographic and climatic variation in Taiwan has inspired our research group to develop a building design that is microclimatic and geographic dependent while it can be a sustainable and healthy one. In addition, we also attempt to setup an evaluation system for the sustainable and healthy building.

2.2 Healthy Living of Sustainable Building in Subtropical Region

Healthy living is the basic demand for human living. People spend most of their time indoors, whether it is at home, at work, at recreational facilities or other places. Therefore, the quality of indoor environment becomes one significant factor affecting human health. We propose the ultimate goal of a step-by-step development from healthy building to sustainable building.

Construct a healthy building environment with good indoor environmental quality (IEQ) to meet the human health requirement should comprise of many indicators. An integrated IEQ control program also should consider all stage of building lifecycle: design, construction, operation, and maintenance. The subtropical climatic characteristics have some potential risks such as heat stress, microbial contaminations, and higher emission rate of organic compounds in our building environments. Therefore, these IEQ indicators and our susceptible characteristics should be taken into account when constructing a healthy and sustainable building in subtropical region.

2.3 Comprehensive Approach Proposed for Designing the Sustainable Building

The comprehensive approach proposed for designing the sustainable building in Taiwan is composed of the following. First of all, the design must reflect the microclimatic and geographic variation. Secondly, it should also provide a healthy environment with proper control of physical, chemical and biological factors affecting human health. Finally, the consideration of meeting the criteria for green building, such as the energy and resource management, ecological planning and the amenity of the building should be included. We suggest such an operation process be a comprehensive approach for designing the sustainable buildings. How to control the living environment with the variation of natural frequency to locate in the health zone of the wave is the ultimate goal of the research with the new building concepts.

3. METHODS - THE CFD AND FULL-SCALED CLIMATE CHAMBER APPROACH

3.1 Evaluation Method in Design Procedure—CFD Simulation

Computer software is used in design process to further evaluate the effects of different physical environments. By input of different boundary conditions, the results can easily reflect the variation of different microclimate and geography.

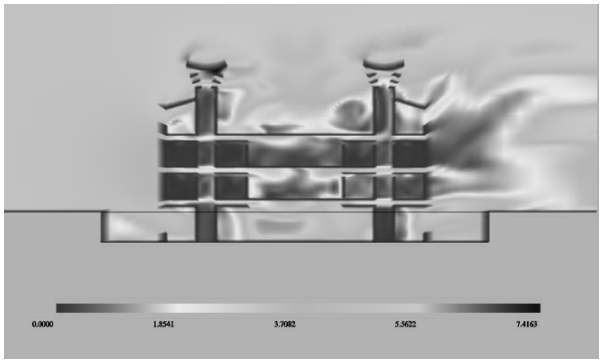


Figure 2 CFD solution for an experimental sustainable building

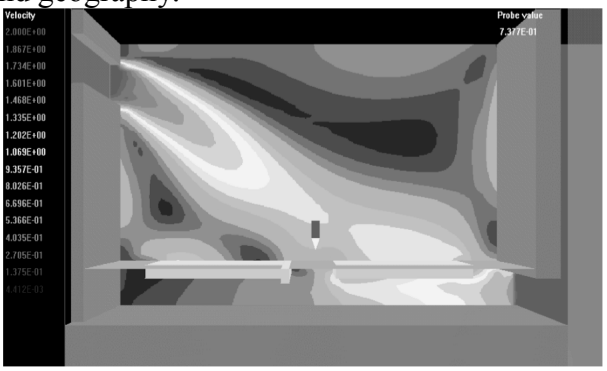


Figure 3 CFD simulation on the new living model room in Taiwan

Figure 2 shows the profile from an experimental case where 2 different design strategies are used to achieve a level of satisfactory natural ventilation. CFD is applied to compare whether there is still any pitfalls between these 2 approaches. Figure 3 shows the flow pattern of the model room, the results supply the comparison data for the experiment studies. The ventilation for the model room is the experimental concept of the new ventilation and the thermal control strategy. A CFD profile is to assist, after taking into account the thermal and ventilation effects in the regions, the actual design for the renovation.

3.2 New Controlling Strategy Approach —Full-Scaled Climate Chamber Test

The climate chamber can provide different climatic status by controlling factors. Therefore, the full-scaled climate chamber can provide the environment simulation with the controls of outdoor temperature, humidity, velocity, pressure, sunlight, outdoor soundscape and the building envelope heat loading. To realize the performance of the new model, the chamber also can monitor the indoor flow pattern, temperature, humidity patterns, air cleanness capability, ventilation efficiency, sound frequency, pressure distribution, illumination distribution and building materials.

The design of the system last for two years to collaborate and set-up the framework. Begin to construction in August, 2000 and finished in May 2001. The experimental items include:

24 solar terms corresponding, plants and sun light, performance of indoor environmental quality, performance of construction and indoor health in biological factors. The chamber is located in Archilife Environ-Control Research Center of National Cheng-Kung University. The research projects all to look for the sustainable living system in Taiwan.

3.2.1 Ten Controlling Factors in the Model Room. The climate chamber in the research center is setup for the new controlling strategy of sustainable building. Thus, the more flexibility and control-ability is the characteristic of this chamber. The factors includes, (1).Vertical planting system (Symbiosis Living ENV), (2).window shutters, (3).floor openings shutters, (4).vent-floor, (5).the wall-modular of acoustics control, (6).furniture, (7).stack ventilation and VENT tower, (8).Indoor vent-shutters, (9).passive vent-shutters, and (10).the clothing control. Therefore, the control variables are from outdoor green tower to the indoor environment control, in the topics of ventilation, thermal comfort, healthy acoustics, different illumination and the new living types for sustainable living. By different controlling factors and the results of the climate simulation in the place of Taiwan, we can improve the controlling strategy for better indoor living environment.

3.2.2 Climate Simulation with the Variation of 24 Solar Terms in Climate Chamber. In order to find out the new model of sustainable building in Taiwan, the microclimate and the geographic situation are both two major topics in the researches. As the figure 1 shows the year variation of the climate conforms to the 24 solar terms in old Chinese calendar. Therefore, to compress the yearly climate-variation in the research into one month is the proof of the chamber capability. The simulation is set to look for the solutions of the new concepts of buildings in Taiwan's climate. The whole period, we called it "long modular", takes one month with the climate control, real time monitoring, the control of the window, one person living in it and the questionnaire. Thus, the information can provide the research group to analyze the adjustments of controlling factors made the building more healthy and sustainable.

4. RESULTS

Through 3 months to modify the stabilities of the climate chamber, and 6 months of the first model to modify, the results can be conducted into two parts, the tree effect for controlling the thermal exposure, the effectiveness of marble humidity control system.

4.1 The Tree Effect for Controlling the Thermal Exposure in Subtropical Region

Hot and high humidity climate is the most important problem need to be solved in Taiwan. Therefore, with the data of rain forest in tropical region, the temperature stably maintains in 28 degree in Celsius. The same situation appears under the big covers of banyan. The former researches proved the effect of cooling effect with the mechanism of transpiration effect of plants. The effect , we call "Tree Effect" utilized in the building facade , could maintain outdoor thermal environment from the range of 14.1℃～31.8℃ to the range of 17.6℃～29℃. Table 1 shows the results of the full-scaled climate chamber experiments with the weather simulation in 24 solar terms. The bold curve shows the outdoor temperature. If we delimit 24℃ is the neutral line of the temperature, the tree effect can effectively control hot temperature below 29℃, located in the thermal comfort area with the wind correction by ASHRAE Psychrometric Chart.

Table 1 Comparison of the temperature results of 24 solar-terms experiments in the controlling model room.

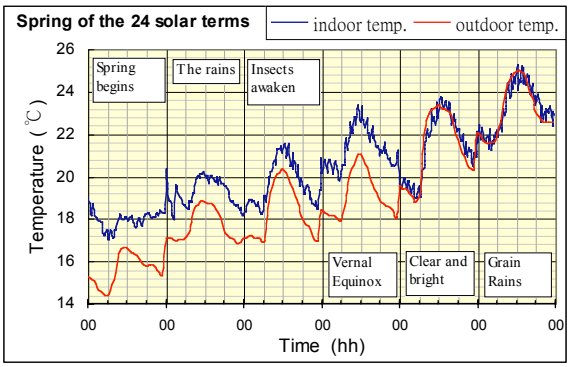
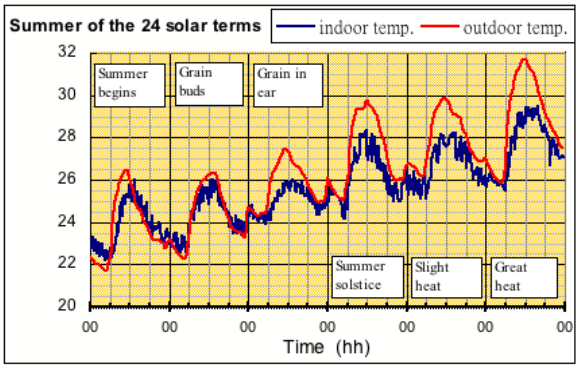
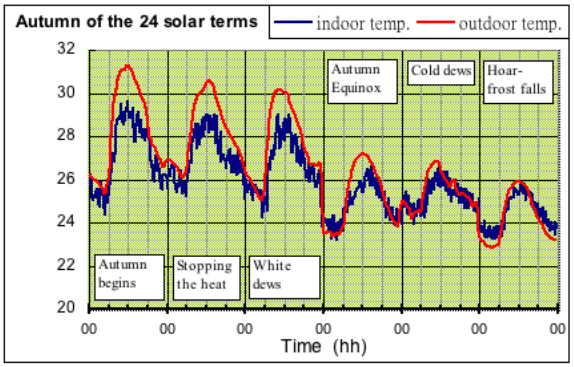
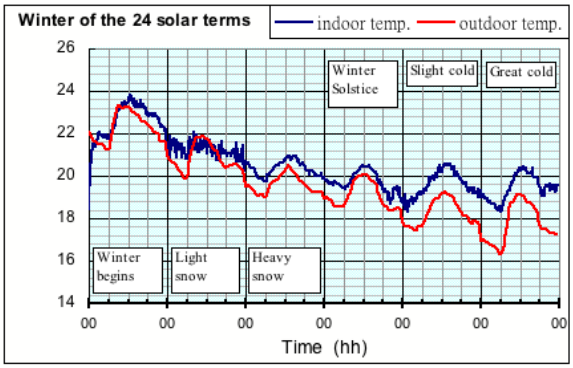
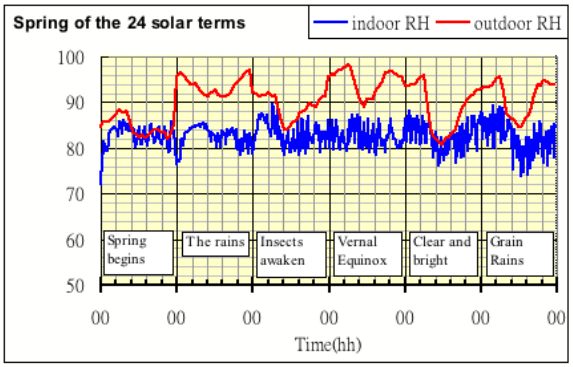
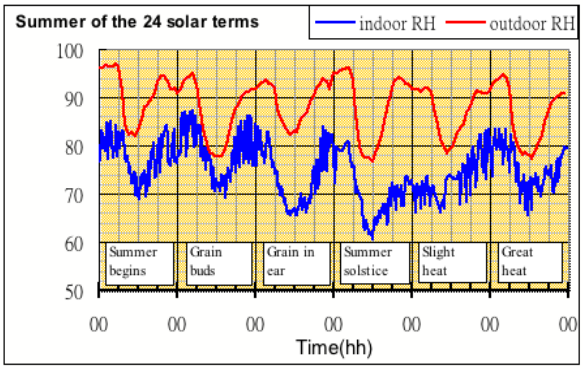
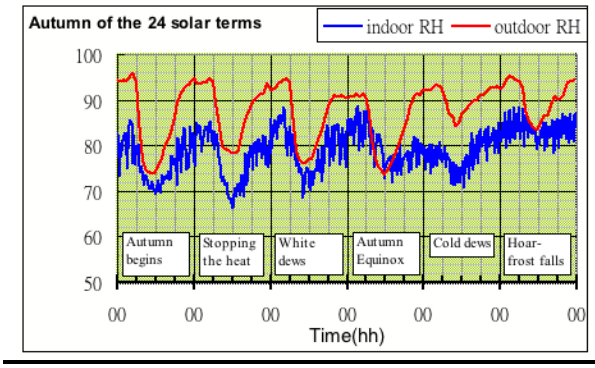
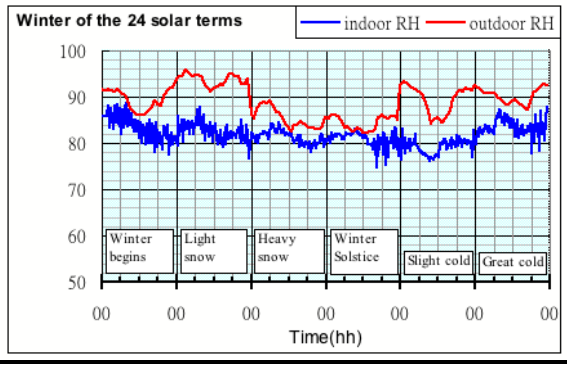
Spring Time	Summer Time
	
Autumn Time	**Winter Time**
	

Table 2 Comparison of the relative humidity results of 24 solar-terms experiments in the controlling model room.

Spring Time	Summer Time
	
Autumn Time	**Winter Time**
	

4.2 The Marble Humidity Control System for Stable and Suitable Indoor Environment

According to the fundamental research of Archilife Research Foundation in 1996 to 1998, The solutions of humidity problem in Taiwan are the strategy combined the effectively natural ventilation design and the material humidity control. The solution is to adopt marble material to reduce the relative humidity of indoor environment by the characteristic of absorbing moisture. We design a new ventilation system with the elevated and vent floor with the marble of high porous ratio. Table 2 shows the humidity results of the experiments in 24 solar terms.

In summer time, the ventilation and material system can reduce the RH from 95% to 83% and 80% to 60%. In winter, the system also can provide the healthy and comfort effects of the 80% relative humidity level. That's the critical control strategy for the human health with low risks of biological and physiological factors.

5. DISCUSSIONS

Over the last 8 years, our research group has come to believe that building, a fine partition between human beings and the outer natural environment, should be able to respond to climatic variation and to reflect the local individuality. A comfortable and healthy indoor environment can be achieved through proper construction and equipment designs. The present data of the research still have some barriers to conquer, such as how to increase the effect of the tree, and the situations of long-term climate with high humidity level. The accumulation results need to be proved in the real experimental building. Therefore, the future scope of promoting sustainable building in Taiwan is engage in the local implementation with the perspective application of the subtropical region. We are confident in our own uniqueness in terms of climatic variation and comprehensive designs. At the mean time, we appreciate and look forward to the opportunity of exchanging our data and experiences in further collaboration with colleagues around the world.

6. ACKNOWLEDGEMENT

The authors wish to thank all fellow friends of Archilife Environ-Control Research Center for their endless help in the intensive sampling activity, and the project support of National Science Council (NSC-90-2621-Z-006-011).

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The Application of a Full-Scale Experimental Model in the Climate Chamber in Taiwan - The Space Formation on the Interaction between Environment and Construction

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1. BACKGROUND

Among the different research groups of Archilife Research Foundation, the principal objective of the History and Culture Group is to explore issues ranging from differences between Chinese and western cultures, a critical reflection on modernity and modernization, the concept of nature, and a 'symbiotic' study of Taiwan's aboriginal culture. The efforts of the Space Planning and Construction Group rests largely in study of physical situation of the 'symbiotic environment' as the spatial frameworks for other research groups. More importantly, it attempts to link indigenous knowledge, one of the focuses of the History and Culture Group, to scientific testing and practice.

1.1 Local Culture and Natural Conditions

Taiwan's aboriginal culture not only reflects the characteristics of the landscape and climate of Taiwan, but also includes indigenous knowledge which could be used in future development towards sustainability, though this has so far been neglected.

In addition to aboriginal culture, Han culture brought to Taiwan over the past three hundred years by Chinese immigrants also forms the basis of contemporary life on the island. In fact, the earlier agrarian system used by Han settlers was directly based on the ancient Chinese peasant civilization, and thus is very different from the Western urban civilization based on the development of city-state. Despite the fact that nowadays 70% of the population in Taiwan lives in cities, elements from traditional society still persist in daily life. In light of this, cultural knowledge from the agrarian society is still valuable for future sustainable development.

As the result of changes in the earth's crust and migration of species during the last Ice Age, Taiwan has a geologically young landform with an ancient ecosystem. Taiwan is a prime example of ecosystems in the Northern Hemisphere. Such natural conditions have given Taiwan very rich biodiversity. In a similar way, the Chinese immigrants who came to Taiwan for economic reasons or because of wars have contributed, together with the aboriginal population, to the cultural diversity of Taiwanese society. These constitute important resources for sustainable development.

1.2 Reflection on the Consequences of Economic Development in Taiwan

The success of Taiwan's economic development over the last few decades has been recognized worldwide. However, the price paid for this so-called "economic miracle" has been a dramatic impact on the environment and heavy social costs. Faced with the impact of globalization in addition to its economic success, Taiwan today needs to revise its public development policy, to consider environmental protection as its primary goal and to redress the imbalance between urban and rural development.

High density and mixed-use are the main features of urban condition in Taiwan. To certain extent, this reflects the particularities of urban life in the East. But in fact, our life culture in some degree is still struggling and compromising with impact and conflict caused by urban development in the technical progress.

Based on the global trend of caring about the ecosystem and sustainable development, we expect to see Taiwan develop a symbiotic environment in keeping with its hot and humid climate, reassess the essence of indigenous cultural life and connect it to state-of-the-art technology, in order to attain the goal of localization of "sustainable building". The efforts of the experiment discussed in this paper are based on the scale of a living unit and present a full-scale model room in the climate chamber as the starting point for further development.

2. CONTENT AND CONCEPTS OF THE RESEARCH

2.1 Scientific Application of Sustainable Development Strategies of Aboriginal Living Culture

This project represents the collective efforts of different specialized fields ("History and Culture", "Physical Environment", "Space Planning and Construction ", etc.). Under the concept of sustainable development, we have summed up the following operational strategies:

1. Strategy I: to take the whole culture and environment as the scope of critical thinking, to continue the aboriginal cultural spirit and develop the concept of "symbiotic environment" for future practice.

2. Strategy II: to collect materials and build a database for environment-related issues using scientific methods and, in conjunction with environmental approaches derived from aboriginal culture, use the full-scale model room in the climate chamber to simulate the local environment and evaluate building methods.

3. Strategy III: to share the results of the full-scale experimental model project with other research groups in order to provide a basis for further efforts in addressing next-generation environmental issues with aboriginal culture.

2.2 Survey of the Local Microclimate and Use of Materials

A weather station was installed at the Fu Long elementary school in Fulong district, Taipei County to conduct continuous monitoring of environmental factors. According to study results and analysis, temperature is steady and humidity low in January and February, it is windy and mildly humid from March through June and September through December, and temperature and humidity are high in July and August. A full-scale climate chamber was constructed and experiments conducted based on these climate patterns.

2.3 Research Objective of the Full-Scale Experimental Model in the Climate Chamber

2.3.1 Purpose. The main aim of designing and constructing a full-scale experimental model in the climate chamber is to offer an architectural prototype appropriate for local modular building. The experimental system – an artificial weather testing device - is composed of a climate chamber, a model room and an environmental simulation and monitoring system.

2.3.2 Research program. The Space Planning and Construction Group conducted the following tests in the climate chamber:

a.Selection of component materials and design of component details for an in-fill system:

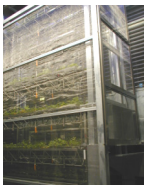
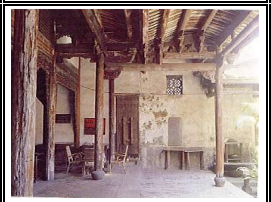
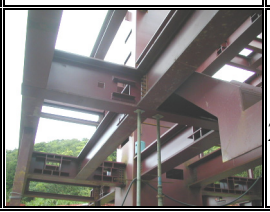
1. Selection of component materials;
2. Study of component forms;
3. Detail design of joints with the sporting system of steel structure.

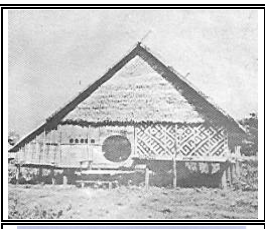
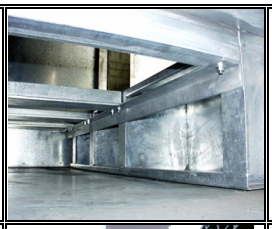
b.Construction and testing of full-scale experimental model:

1. Fabrication of components: exterior wall, interior partition, and floor;
2. Different combinations of the component framework and interchangeable surface materials;
3. Component testing.

2.4 Concepts and Principles of Design

The design of the modular building is based on scientific data provided by the Physical Environment Group, and applied to a full-scale model. The concepts used include "Tree Effect", "Material Effect", "Deep-shaded Balcony", "Elevated Floor", "Ventilation Tower", etc. In addition, the twenty indices compiled by "The Declaration of SONGS (Specifications of Next Generation Settlements)" are also taken into account. Below is a brief presentation of the concepts derived from Taiwanese aboriginal culture.

	Concepts derived from aboriginal culture	Applications in the full-scale model room	Comments
Tree Effect			1. Inspired by the transpiration principle of plants, the building's exterior walls have the same function. 2. Following the ideas of "symbiotic environment", plants will be grown in the Planter Tower.
Material Effect			1. Applying the dehumidification principle of using stone materials to regulate interior environment atmosphere. 2. Making good use of the physical properties of stone to build a comfortable living environment
Deep-shaded Balcony			1. Predicting living behavior in the symbiotic ecosystem, and providing spaces for semi-outdoor activities. 2. The dimensions and shape of shades are designed based on scientific data.

Elevated Floor			1. Taking into account the hot and humid climate, elevating the building as was traditionally done, in order to facilitate airflow and attain effects of cooling and dehumidification.
Ventilation Tower			1. Drawing in naturally fresh air due to pressure differences and construction shape. 2. Airflow is facilitated and promoted in the channels, which form a circuit together with the floor system.

3. OPERATION AND TESTING

3.1 Environmental Conditions for Installation of the Full-Scale Model Room in the Climate Chamber

Below is a brief description of each component unit and operations realized:

3.1.1 Climate chamber. The climate chamber is programmed to reflect subtropical weather conditions in Taiwan.

3.1.2 Vertical planting system test site. There are currently twelve planter racks on which green plants are grown. By simulating the high-temperature subtropical environment, the experiment aims to test the effectiveness of the "Tree Effect" as an active method in regulating temperature. The planters' structure is designed in a way to be able to study and develop local models of Double Façade buildings.

3.1.3 Bathroom test site. In accordance with the new community model based on symbiotic environment, the concept of wet/dry separation is adopted in the design of the bathroom. It is also considered to integrate this with the function of ventilation through the building's exterior walls and the ventilation tower in order to maximize dehumidification.

3.1.4 Model room unit. In order to facilitate the installation of an in-fill system and to adapt to future experiment requirements, the present module laboratory has adopted a dry wall system; the whole construction is sound-proof and equipped with interchangeable mechanisms; the modular system facilitates the production operation; the floor is covered with stone in order to enhance the effect of dehumidification; adjustable aluminum venetian blinds are installed on the double facades, and screens are fixed to prevent insects entering.

3.2 Construction and Material of the Experimental Model

The experimental model is a modular building which comprises a bedroom, a bathroom and divider walls on all four sides of the module. In order to facilitate the necessary and frequent interchange of material during the experiment, the model is built in removable sections.

3.3 Experiment Items and Interactive Experience of Space Formation

The experiment conducted in the full-scale experimental model consists mainly of the simulation and testing of space formation and the operation of materials. Following are

discussions on the interactive experiences in each of the three parts of the experimental model.

3.3.1 Vertical planting system. The vertical planting system was installed on the exterior of the model construction, and the test showed that this method of building would add too much to the weight of the construction. It is therefore suggested that the planter towers should stand independently system separate from the structure system of building and be attached to the building by means of connectors. This would not only be better for construction but also easier to the install of the planter towers.

3.3.2 Bathroom. The wet/dry separation system adds more comfort to the physical environment of the bathroom. In the "wet" zone, the floor is a single block of stone and thus waterproofing. The only drawback is its weight. It is therefore recommended to keep the present building method but to use an alternative material which is lighter but as waterproof. The "dry" zone benefits from a natural ventilation system thanks to the elevated floor, and has a better construction form than standard bathrooms using a mechanical ventilation system.

3.3.3 Model room. The ceiling surface and divider walls are covered with 'removable' soundproof panels with some user-friendly properties unavailable in most current partitions : it is quick and easy to add or remove panels to replace the in-fill material or change the configuration as the project demands. In addition, no further finishing process is necessary after the boards are installed.

4. DISCUSSIONS

By applying the concepts of sustainable building, the research groups under the umbrella of the Archilife Research Foundation have used and transformed aboriginal knowledge. With a broad view of building methods and materials available, we not only take a positive attitude in response to different environmental issues, but also actively work to create a model for sustainable building in subtropical regions. The project of the full-scale experimental model represents the result of our efforts. Based on the results of the experiment mentioned above, we conclude that the structure of the space in accordance with sustainable building should include the following principles:

1. The creation of sustainable building must be based on a full understanding and careful application of aboriginal cultures.

2. The creation of sustainable building should be integrated into the existing social context with vision to the future.

3. The objective of space formation is to solve both accurately and efficiently the problem of environmental constraints and to appear in a suitable way.

4. The combined application of concepts of sustainability and space formation should be embodied in the harmonious relationship between the building and its environment.

We hope that the results of the above-mentioned experiment will lead to a transformation in the behavior pattern of indigenous settlement culture and be applied to larger scales of space , such as the community, urban or rural areas, or the regional and national land planning and the readjustment of national developement policy. In addition to this, we hope that this experiment will serve as a base for further research on the physical environment and ecology.

The full-scale climate chamber represents only a small step in space creation. Based on this experiment, we plan to go further and start working on larger-scale spaces and issues. Hope in the conference of 2004, we will be able to present you with the results of such challenges and we look forward to your comments and critiques.

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Movements of the Environmentally Symbiotic Housing Theory and Practices in Japan

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1. BACKGROUND

1.1 Beyond the "Scrap and Build" Housing

During the last decade, the Japanese building industry has maintained an average construction level of approximately 1,400,000 dwelling units per year (**Fig.1**). These homes have an average lifespan of 30 years (**Fig.2**), a significantly short period of usefulness compared to European or American average. This is however not surprising for Japanese, because the lifespan of urban timber houses used to be very short due to frequent fires or to the natural disaster caused by typhoons and earthquakes.

A historian of lifestyle reported that the expected lifespan of timber townhouses in Edo Era (former Tokyo during 1600-1868), was as short as merely 3 years in average (Sugiura, 1998), according to accounting reports of carpenters. However, they had a very quick and prefabricated rebuilding system through forestry-timber manufacturing and supply industry within a cyclical eco-system（Ishikawa, 1997）. That could only be possible due to totally natural materials of houses, produced and supplied by the local industry in the adjacent regions.

Such tradition of wooden houses could be a reason of the short lifespan of housing in Japan. In addition, other post-war social and administrative systems, including housing loan, pricing and tax system on real estate, and the extremely high inheritance tax (max:70%), have been the major incentives to demolish the houses before they reach their potential lifespan. The result is the quite high proportion of new construction (55%) to renewal (45%) in terms of floor area built per year in 1990 (**Fig.5**). Therefore, the industry's massive output is largely dependent upon what has been called the "scrap and build" attitude.

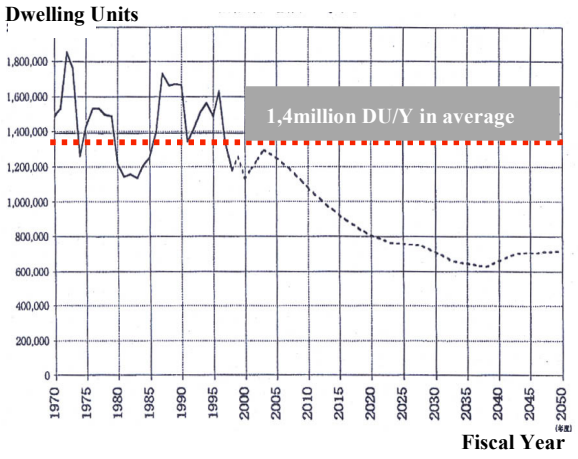


Fig.1 Annual New Construction of Dwelling Units in Japan (Mitsubishi Research Institute)

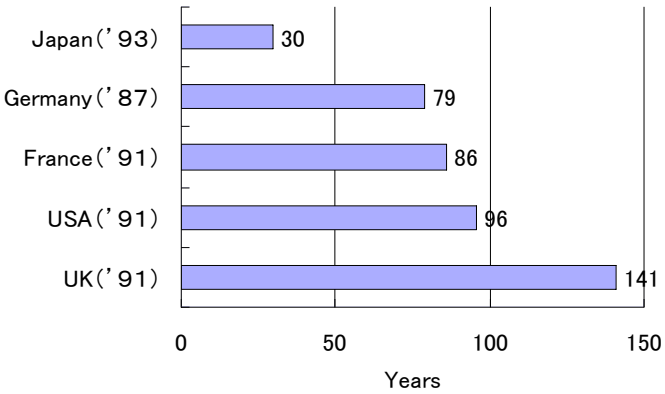


Fig.2 International Comparison of the Average House Life Spans (Management & Coordination Agency, 1993)

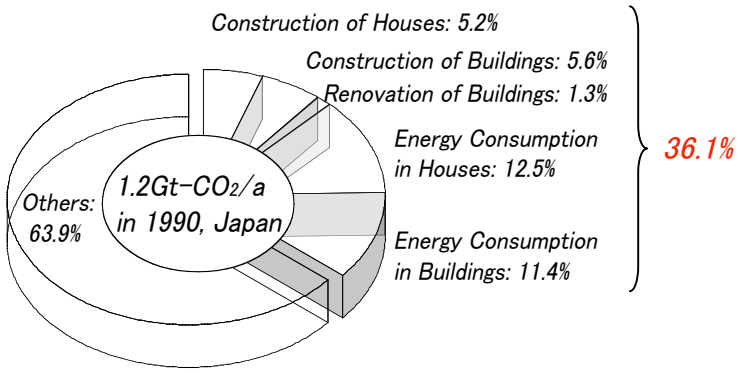
1.2 Housing and Global Environmental Issues in Japan

While this rapid rate of housing production has been an indispensable propeller of the post-war Japanese economy, it has been a source of grave problems as well. These problems include the consumption of large amounts of energy and natural resources, over 90% of which are imported from abroad, during the whole lifecycle of housing (**Fig.3**), and the resulting minced and mixed disposal of demolished houses, unable to put into the material recycling process. These were scarcely recognized as environmental issues until the beginning of the 90's, when the global environmental problems became an internationally political issue, which Japanese government could not overlook anymore.

1.3 Problems of Housing Quality

It is true that post-war Japanese housing production has developed very rapidly both qualitatively and quantitatively. However, the following qualitative aspects of housing bring to light the many issues still to be coped with in this country.

- Lager size of a dwelling unit (Governmental guideline for a household of 4 person: 72㎡)



CO_2 emissions were assumed using the 1990 Input/Output table of Japan (T.Ikaga)

Fig.3 CO2 emissions by construction and operation of houses and buildings in Japan

- Longer durability and better adaptability according to the site's and residents' requirements
- Appropriateness of housing techniques according to the regional and residents' conditions
- Health and comfort of the indoor as well as the outdoor
- Improvement of town-scaping and natural landscaping
- Costs of measures related to the above

Japan has been facing a decade of economical recession, and the demographic forecast shows a drastic decrease of population after 2007(**Fig.4**), that will bring far less demand for new building construction works in Japan in long term as shown in **Fig.5**. Such situation will automatically create national demand for high-quality housing that deals with the above mentioned issues.

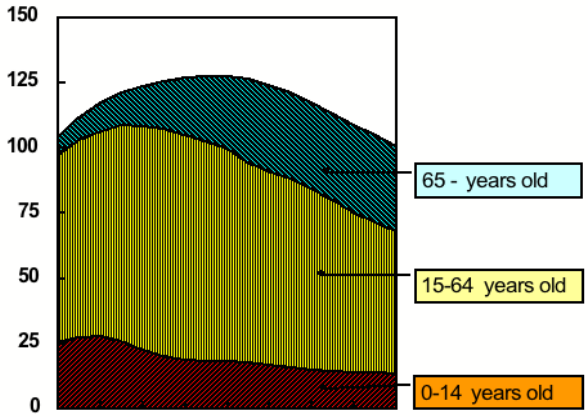


Fig.4 Assumption of Japanese population

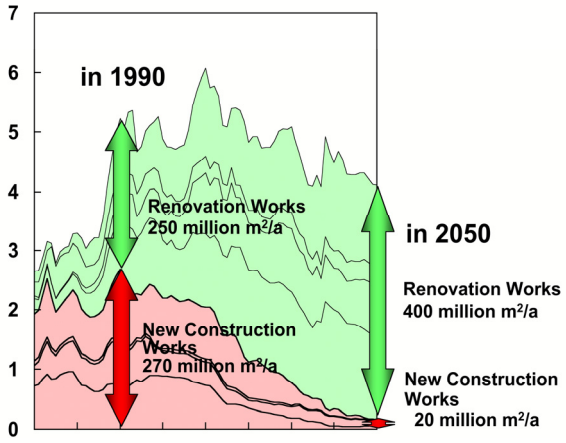


Fig.5 Decrease of new construction Works by floor area (T.Ikaga, S.Murakami, University of Tokyo. 1999)

1.4 Towards Sustainable Housing and a Sustainable Society

It is, therefore, the responsibility for all the stakeholders, involved in housing production, distribution, construction and use (including clients, owners, developers, users, authorities, designers, industry, contractors, maintenance organizations and institutions for education and training), to be aware of the environmental problems confronting housing and community development for a sustainable society. At the end of the 80's in Japan, there arose a tendency of thoughts to recognize the necessity to come up with all these issues of resource, energy, immediate loadings, health & amenities as a comprehensive environmental issue to support for the creation of a sustainable society. The former Ministry of Construction took a strong initiative to guide this tendency towards creating a new national policy, under the banner of "Environmentally Symbiotic Housing (ESH, hereinafter)".

1.5 Movement of the Environmentally Symbiotic Housing

Having foreseen such a state of affairs, in 1990, a group of professionals and firms from public and private sectors joined forces, first functioning as a research body then as an organization for the promotion and realization of ESH from north to south in Japan. For six years it studied, from a wide variety of approaches, technologies and organizational systems that help address problems in housing and community development. National subsidy schemes set up during this period has helped to carry out over forty projects around the country. These are primarily projects by public corporations and independent groups, with the completed works playing an important role in furthering the understanding and experiencing ESH. Among those, the FUKASAWA Symbiotic Housing Complex is the most successful and symbolic project that was planned and implemented during this early stage (**Fig.6**). And recently, a complex of 50 public housing units on a sub-tropical island, Yakushima, has been built under the banner of ESH in South (**Fig.7**).

1.6 Development of the Movement

This movement has already 12 years experiences and has been run by the Association of Environmentally Symbiotic Housing (URL=**http://www.kkj.or.jp**) since 1997, uniting member groups of diverse business types and conditions, design methods, construction techniques and marketing methods. Whether involved in the planning, design, production, marketing, or maintenance of housing and community, member groups share a common destination that is to investigate, propose, create, and evaluate ESH and related methods, systems and attitudes. In cooperation with the Ministry of Land, Infrastructure and Transport, as well as with the related Institute of Building Environment and Energy Conservation (IBEC), the labeling and evaluation guideline of ESH was established in March 1999 (**Fig.8, Table 1**). Since then, more than 80 types of houses and housing complexes have been evaluated and labeled.

2 DEFINITION AND OBJECTIVES OF ENVIRONMENTALLY SYMBIOTIC HOUSING

According to the official definition, set by the Ministry of Construction in 1991,

> *an Environmentally Symbiotic Housing shall be developed from the standpoint of preserving the global environment by conserving energy and resources, while reducing waste at the same time.*
>
> *It refers not only to housing itself, but also to the surrounding local environment. Its next goal, therefore, is to exist in harmony with both natural and man-made surroundings, as well as to provide residents with amenity-rich healthy life, thus encouraging them to participate in construction process, and then taking care of the environment.*

The following three basic objectives must be realized to achieve Environmentally Symbiotic Housing：

A) Global Issue: Protection of the Global Environment (*Low Impact*):

This includes energy and resource conservation and minimum waste production in various ways and upon various levels. Especially energy and resource consumption of the building construction and operation should be promptly minimized to meet the COP3 requirements. Such activities already have some part in most people's daily lives, but they should be organized on a neighborhood and regional scale as well, and be thought about and practiced by every resident. The huge amount of concrete rubble produced when buildings are demolished, is an example of building waste that must be recycled. Such recycling should not be planned case by case; in order to achieve a significant difference, it must be established as a social system.

B) Local Issue: Harmony with the Surrounding Environment (*High Contact*)

The etymology of the word "landscape" suggests not only the beautiful scenery of a location, but its condition in every sense, including its climate, its geography and the organisms that inhabit it. Building ecology reveals the relationship among the human beings, the building and the environment as a whole, for the sake of creating the best balance of human habitat. Therefore, it is essential to investigate environmental elements such as light, wind, water, earth, and organisms, and to apply the findings to development decisions. In other words, development should be appropriate to the history, landscape, and inhabitants of the site and its surrounding area. This will influence, too, the kind of community to be created there for a sustainable society. This issue should be a top priority of the country's policy to be implemented.

C) Residential Issue: A Healthy Residential Environment with Amenity (*Health & Amenity*)

Since the mid 90's, the relationship between housing and residents' health has become a serious social issue, due to toxic chemical stuffs used in indoor building materials and components. These brought houses the risky potential, especially within indoor spaces that are increasingly airtight. The air-tightness of housing had never been the issue in the building history of Japan, where the openness for summer's hot and humid climate was the top priority, and the idea was brought from North America to cope with energy saving for heating. Without actually noticing it, our homes may produce chemical substances, mold, and dust linked with allergic reactions as eczema. The elderly, the handicapped, infants, and housewives, who spent the longest hours at home, are especially at risk. Closely related to health is the idea of "comfort", with light, temperature, humidity, and ventilation being some of the issues that need to be reexamined as well.

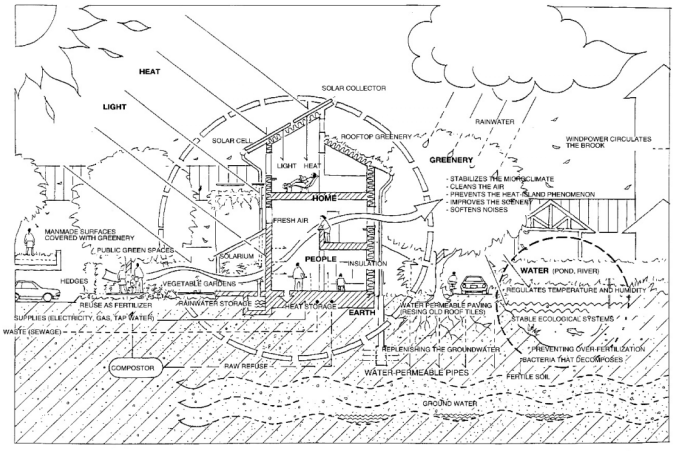
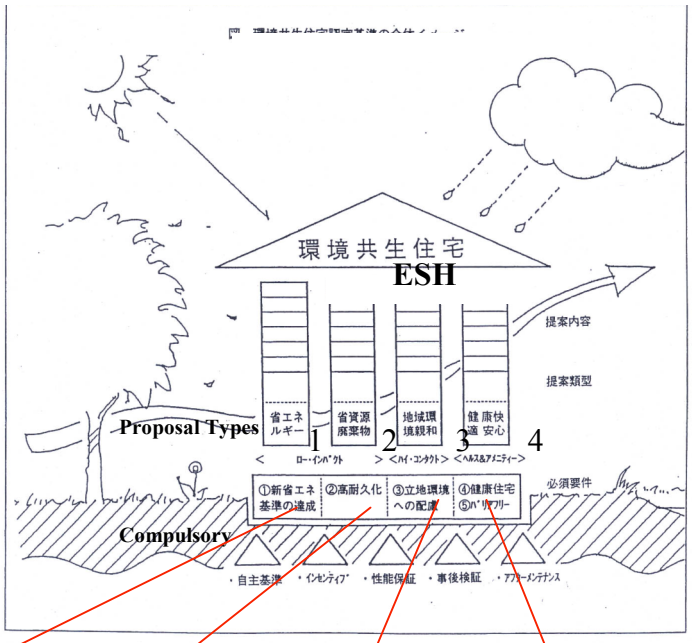


Fig.6 Holistic Image of Environmentally Symbiotic



Fig.7 Yakushima ESH

Fig.8
Structural Image of
the Environmentally Symbiotic
Housing Evaluation Guideline
(Iwamura, 1998)



To be labeled as ESH, it shall meet first every compulsory performance requirements, and at the same time, shall be provided with higher performances of at least two proposal categories, shown as the columns in **Fig. 6.** The submitted proposals are to be evaluated and judged by the committee of experts, according to the guideline.

Table 1: The Basic Frame of the Environmentally Symbiotic Housing Evaluation Guideline (as of 1999)

Proposal Types	1.Energy Saving	2.More Effective Use of Natural Resources	3.Compatibility and Harmony with the Local Environment	4.Health and Amenity – Be Safe and Feel Safe
Proposal Contents as Examples	1) Greater efficiency in reducing heat losses 2) Greater efficiency in controlling solar radiation capture 3) Passive use of solar energy 4) Active use of solar energy 5) Efficient use of unused energy 6) Use of highly efficient equipment 7) Miscellaneous	1) More durable skeleton 2) Structural and building methods for flexibility 3) Low emission 4) Active use of recycled building materials 5) Highly effective use of water resources 6) Sorting of household wastes 7) Miscellaneous	1) Better harmony with the local ecological system and environment 2) Greater consideration for the natural water system of the area 3) Greening efforts 4) Creating rich buffer spaces between indoor and outdoor 5) Greater consideration of townscape 6) Integration of the local culture and regional industry 7) Miscellaneous	1) Through universal design both indoors and outdoors 2) More suitable and adequate ventilation 3) Through choice of safe and eco-materials 4) High sound insulation efficiency 5) House performance guarantee though ongoing property management 6) Information services on housing 7) Miscellaneous

	Low Impact		**High Contact**	**Health & Amenity**
Compul-sory Perfor-mances	(1) Conformity to the Energy-Conservation Standard as of 1992	(2) Long-life Durability; Conformity to the GHLC* Standard as of 1998	(3) Consideration regard-ing the surrounding envi-ronment	(4) Conformity to the guideline for indoor air quality (5) Conformity to the barrier-free design stan-dard of GHLC*

*GHLC=The Governmental Housing Loan Corporation

Source: Institute for Built Environment and Energy Conservation, 1999

3. IN CONCLUSIONS

When housing is thought about from the vantage point of symbiosis with the environment, the problems that plague modern housing – and architecture in general – become obvious. Along the path of progress, we have thought fit to discard or forget the traditional ways of living that were based on biological knowledge. These methods were in fact protecting the richness of the environment, supporting the continuity of peoples' lives through the preservation of ecological balance. While solving these problems in one sweep would be an overwhelming and difficult task, it is important to start with things we can do in our immediate surroundings.

In the aftermath of the Great Hanshin Earthquake, when we heard of how the victims reacted to this hitherto unthinkable disaster with spontaneous, local cooperation, we were made to recognize how important it is to build not only large-scale systems, but also smaller, independent systems of energy and water distribution. It showed us, too, in a extremely striking way, the true meaning of "living together" with our neighbors, and the importance of maintaining strong ties with each other. When a neighborhood is created through participation by all the residents, such relationships could develop and flourish. In order to realize a sustainable society and development, the element of human relationship is impossible to ignore. This is one of the most meaningful cultural aspects of the Environmentally Symbiotic Housing.

The issues concerning ESH touched on above are not extraordinary in themselves. They are basic ideas from which most discussion on housing and neighborhood start. It is time to use these ideas, reconstructing our techniques, administrative systems, and attitudes accordingly.

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Sustainable Environment for Whom, with special reference to cities in East Asian region

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WHERE WE ARE

The dramatic changes in the 20th century was unprecedented. Supported by rapid technological innovation, the West was able to sustain its continuous economic growth with the expansion of its frontiers and markets by colonization and by the ruthless exploitation of nature and her resources.

Paul Ehrlich, a pioneer on environmental awareness, published *Population Bomb* in 1968. He predicted population explosion of a Malthusian proportion. Soon after, members of Club of Rome published *The Limits to Growth* in 1972 expressing serious concern in the mis-use and limits of resources. "If the present growth trends in world population, industralization, pollution, food production and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next one hundred years."

With population explosion and the insatiable demands by the affluent of more consumer products, the present development model is clearly unsustainable. There are many clear warning signs from ozone depletion, de-forestation to over-fishing. Furthermore, income disparity in the last millennium has greatly increased between rich and poor countries. In recent years, income disparity has also widened within countries even in the advanced economies.

This single-minded focus on the pursuit of a high-tech global future and excessive consumerism has left in its wake an unsustainable exploitation of the earth's global resources. This has resulted in a lop-sided allocation of resources and amenities at the expense of the poor and the underprivileged. This has frequently been put across as the unavoidable formula of capitalist-styled economic development. The notion of challenging the accepted norm is therefore both fundamental and crucial.

SUSTAINABILITY

There are now many non-governmental organizations (NGO) operating internationally. They range from the well-known mass-based *Friends of the Earth* to environmental group *Greenpeace* which is renowned for its confrontational stance towards governments as well as numerous research institutes. Their dedicated efforts and voices are now being taken increasingly seriously. The recent surprised request to Greenpeace by the Indonesian government to assist in stopping the export of illegal logging

is most interesting.[1] This should also raise the ethical issue of the need to punish the buyers of these illegal logs, as effectively as the enforcements against copyright pirating by western countries. However, international intervention alone is not enough. Strong local activism and host government supports are essential for effective implementation.

In recent years, recycling has really caught on. Cities are competing with each other to prove their achievements and commitments. According to authors of a recent book entitled *Cradle to Cradle* [2] there are two major unresolved issues. First, most present recycling can best be considered as *downcycling*, as the process reduces the quality of a material over time and can only delay temporarily the material for becoming waste in due course. Second, various toxic and harmful substances are often melted into the products and cannot be salvaged after their current usage. Great efforts and public commitments are needed to provide viable alternative solutions.

In order to be truly self-sustainable, we need eco-effectiveness in recycling. We must be "working on the right things … instead of making the wrong things less bad" and to design system that regulate themselves with continuous self re-generating capability. With increasing pace of technological advancement to achieve this appears increasingly feasible. However, serious commitments with wide public supports and enforceable legislations are necessary. The authors poise an interesting question:- "what would have happened, we sometimes wonder, if the Industrial Revolution had taken place in societies that emphasize the community over the individual, and where people believed not in a cradle-to-grave life cycle but in reincarnation?"[3]

RE-DEFINING LIMITS

Since the seventies, computers, internets, E-mails and hand-phones have drastically altered the pace and reaches of technological and economic development. The most spectacular examples recently are the rapidly developing coastal regions in China. Simultaneously, the rapid changes in contemporary culture, value and lifestyle have great universal influences, notwithstanding the increasingly strong local and regional resistance. Recent development in China, particularly in Shanghai[4] and other major coastal cities, have also generated a new urban paradigm beyond the grand narratives and utopian concepts of modernism, and is now being much debated by theorists and critics alike.

Rapid technological development and value changes have many important unexpected implications. Together with greater gender equality and universal primary education, it is now conceivable for the world population to be stabilized within the next few decades at a manageable level. This is clearly the single most important issue for long term sustainability. All efforts must therefore be made and prejudices put aside in order to achieve this in the shortest possible time.

Limits of the various key resources need also to be re-defined. Energy shortage may soon be a myth, especially after vehicles can be free from petroleum's dependency. Water will be plentiful with cost effective recycling water treatment and large-scale sea water conversion. Forest can become self-renewable and timber will have to be used more selectively. Fish, like prawns and frogs, will be farmed productively. Metals will be effectively recycled in a self sustained manner. The expanding limits of key resources are vital factors in altering the present mind-set of resource scarcity, and in contesting the need for the powerful to dominate others in order to ensure their continued availability.

GLOBALITY AND SOCIAL JUSTICE

United States is a clear leader in the new global economy of super-scale mergers, down sizing and financial whizz-kids. She has attempted to demonstrate the inevitability of this development model. However, this model has frequently been contested even in Western Europe and Japan. More recently, its creditability has been seriously questioned by strategically located mass demonstrations, the weakening of the U.S. stock market and the serious dislocations in the high-tech and I.T. sectors of the U.S. economy.

Critical voices are now being heard. 'Greed is good' theory is now being seriously challenged. Let me quote Paul Krugmen: "Let me make it clear: I'm not talking about morality, I'm taking about management theory. The new tough-mindedness was enforced, above all, with executive pay packages that offered princely rewards if stock prices rose… a system that rewards executives lavishly for success tempts those executives… to fabricate the appearance of success."[5]

In a recent paper, Arjun Appadurai uses the term *grassroots globalization* to redefine alternative strategies and visions by globalization on behalf of the poor[6] and conceivably is also applicable to the less developed economies. For the poorer countries, the indiscriminate applications of 'one size fits all*'* U.S. style globality and WTO value-loaded formulas can only result in disastrous consequences.

The 1997 East Asian economic crisis is a wake-up call for the region to examine seriously the urgent need for their major revisions. Two much publicized examples are:- first, soon after the currency collapse of several countries in the region, Malaysia defiantly and successfully introduced currency control intervention, and second, the present heated debates have highlighted the possible wide-ranging consequences of China's opening her agricultural market in compliance with conditions of WTO.

Consumerism – this postmodern phenomenon and Jamesonian cultural logic of late capitalism – has distorted values and lifestyles. It has increasingly dominated the urbanscape in the U.S. with mega-shopping malls. Ekon Eshun critically examines the increasing dominance of consumerism and the obsession to shopping. There is an "inherent sickness in our celebration of consumerism … it's not as if there isn't anything to care about anymore. It's just that we'd rather go shopping."[7]

The urban poor exist in every city. Their voices are often suppressed by the manipulation of the rich and the powerful. Cities like Beijing, Jakarta and Bombay also face an explosion of population from the transmigration from the rural areas. In the meantime, international consumer culture has successfully penetrated even urban centers of the less developed economies, when economic development is still at an early stage. To provide the basic needs and amenities for the whole community particularly the poor and to apply these principles to urban conditions we have to expand the concept of equity and social justice by including environmental and spatial justice.[8] We need to poise many ethical questions relating to the rapidly expanding Asian cities. They include:- land allocation particularly for housing the urban poor, accessibility and affordability of public transports, locations of open spaces, and public parks, and the provisions of basic facilities such as health and education.

LETS SAVE OUR FOREST

Everyone will surely agree that we should preserve the tropical rainforest. Their incredible bio-diversity will certainly offer new insights towards the yet unforeseen contribution to and

understanding of the intrinsic complex relationship between nature and science. However, vast stretches of tropical rainforest are located in lower-income countries. In many instances, the rich and powerful – both local and foreign – have exercised great pressure including high-level corruption to clear the forest with ruthless, wasteful and devastating logging for quick profit.[9] This is happening everywhere today from Africa, South America to S.E. Asia. This large-scale destruction will deplete most of the existing timber resources rapidly. What can be done? In this paper, I wish to put forward an out-of-the-box proposal.

The international community must provide adequate financial grants to the respective host governments to insure the preservation of their tropical rainforest. The idea will be similar in principle to the *idle-farm* subsidies generously given to farmers in many developed economies. The forest will have to be properly looked after and regularly inspected for compliance with governing regulations to insure self-sustainability. Illegal logging must be stopped with the full force of the law and with the co-operation of all parties, from host governments, loggers, shippers to buyers. We need urgent action now.

CONCLUSION

To achieve a truly sustainable world and livable environment for everyone are no longer just an utopian dream. It is now realizable. However, urgent actions are needed in many areas. In particular, we will have to stop further ozone depletion, to maintain forest bio-diversity and to stabilize world population. These are challenging tasks and will certainly be met with strong resistance from many influential quarters. To overcome these obstacles, we must identify and find solutions for the numerous complexed issues, develop innovative out-of-the-box strategies and work together with firm ethical commitments.

Let me conclude by quoting from the song *We are the World*:
When you're down and out.
There seems no hope at all.
But if you just believe.
There's no way we can fall.
Well, well, well, let's realize
That one change can only come
When we stand together as one[10]

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Architectural Features for the Environmental Friendly Century

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1. INTRODUCTION

Architectural features in this century should be 'environmental friendly', with protecting the environment being a hot topic. Enhancing the quality of life and improving the living environment is one of the principal policies as emphasized in the Policy Address by the Chief Executive in October 2001. Building green is a shared target of many government departments. 'Green building' is brought about in Hong Kong with many new special features. Examples are:

- Providing more natural ventilation instead of cooling by mechanical ventilation and air-conditioning (MVAC) systems;
- Utilizing more daylight instead of illuminating by artificial tungsten filament lamps with lower efficacy; and
- New light materials but better thermal insulation.

As reviewed by Cohen (1997), environmentally responsible buildings should provide satisfactory thermal comfort conditions, as thermal environmental systems would use much more energy in comparing with those for lighting, safety and security. Overheating in summer is not considered to be too important for energy saving in cold countries. But this is not the case in countries with quite a long summer. There, MVAC systems are required, especially in offices where productivity is important due to the high cost of human resources. Setting criteria on assessing the environment before putting in heating system might work as the government offices had been criticized by the local Legislative Council for putting in heating systems but never turned on for ten years!

Some of the new building designs have integrated the passive control system in an attempt to reach the target of 'environment conservation'. Several innovative architectural features in Hong Kong, including internal building voids, double glazed wall, natural ventilation design and using materials with good thermal insulation would be discussed in this paper. How they give an environmental-friendly buildings will be reviewed. However, the latent adverse effect brought about should also be investigated.

2. NATURAL VENTILATION

Requirements on lighting and ventilation are also described in the Building (Planning) Regulation (Building Ordinance 1997a). They must be provided by erecting one or more windows of at least the allowable minimum area as specified for any habitation area, office

and kitchen in a building or story. The glass window should be at least one-tenth of the floor area. For an openable window, it should not be smaller than one-sixteenth of the room floor area.

Thermal comfort is considered as the most important issue to pursue as the cooling load occupies a large portion of the energy consumption. Introducing natural ventilation is one of the means to maintain thermal comfort for human instead of using mechanical ventilation system. Provided that the orientation of the building and design of openings are appropriate for catching wind, the air flow is able to cool down the internal temperature and also improve the internal air quality by providing some fresh air. The greenhouse gases emitted can also be eliminated. One of the private residential developments in Tung Chung has been integrated with this design feature with larger panes of glass windows and special master layout. It has been awarded the highest honor by Architectural Services Department (ASD) for its success in merging the built and natural environment.

3. GLASS CURTAIN WALL

Besides the thermal comfort, visual comfort is also a big issue. Daylight is frequently introduced through the glass wall and window to minimize the use of artificial lighting, especially for the office towers because sufficient lighting is able to ensure the productivity of the office operation. A better view is also provided at the same time. In order to raise the market value and the rental price, both office buildings and residence are usually accompanied with glazed façade. When solar radiant enters the building, it will be trapped inside the building. Heat gain will be accumulated and it would give rise to increased cooling load so as to maintain the thermal comfort zone. A double glazing system is then created to overcome the problem. Two glass panes are installed parallel to each other, leaving an air gap in-between. Air will be driven mechanically to flow through this cavity to bring away the heat accumulated there. Natural lighting can still be introduced into the building inside. Most of the newly-erected government office towers have been built with this special external wall, for example, the North Point Government Offices, with better integration of utilization of energy.

4. MATERIALS WITH GOOD THERMAL INSULATION

In the Building Ordinance Cap 123M Building (Energy Efficiency) Regulation (Building Ordinance 1997b) , it is prescribed that energy efficiency of commercial buildings and hotels should be achieved by the means of getting a satisfactory overall thermal transfer value (OTTV). It is a measure on the heat transferred through the building envelop taking account of the area of building envelop, the area of openings, the thermal properties of the envelop materials, the orientation of the building and the shading effect from any devices. A Code of Practice (Buildings Department 1995) was issued to provide guidance on how to obtain and calculate the OTTV (in W/m^2). The statutory requirements of the OTTV for the external walls and roofs are not more than 35 W/m^2 for any commercial buildings and hotels.

Apart from applying wind action, using envelop with high capacity of thermal insulation is another way to attain the same goal. Only little solar heat can pass through the building envelop of low heat transmission and good thermal insulation into the occupied spaces. Heat gain inside is thereby minimized. One of the examples for this feature is the Hong Kong Science Park, government's technological project, where the main focus is the use of environmentally responsible materials and reduction in the use of energy. The expected OTTV is only 20 W/m^2, the environmental target of ASD, which is stricter than the statutory requirement.

However, that study was not too correct as pointed out earlier (Chow and Yu 2000). That recommended OTTV equation was developed from the earlier work in Singapore. There is only one season in Singapore while there are four in Hong Kong.

A simpler and more satisfactory equation was given in terms of window-to-wall ratio WWR, U-value for wall U_w (W/m^{2}K), U-value for roof U_f (W/m^{2}K) and shading coefficient for window SC as:

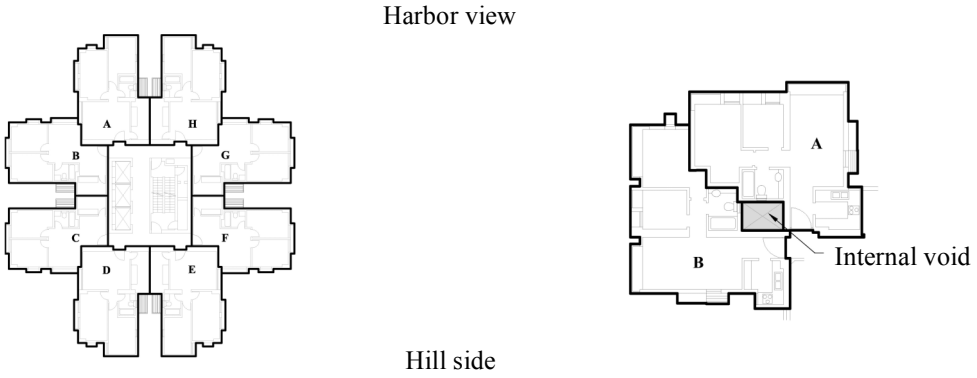
$$\text{OTTV} = 1.96\ (1\text{-WWR})U_w - 2.62\ (\text{WWR})U_f + 143.40\ (\text{WWR})SC \qquad (1)$$

It is revealed in an earlier study that the OTTV equation in the local code is close to the value calculated by an energy simulation program only in the case of concrete roof but not a glass roof which is accounted as the fenestration on the external walls. Thereby, the solar heat gain through skylight is also significant in determining heat gain through the building envelope. Further study should be carried out for the establishment of OTTV equation for glass roof.

5. INTERNAL BUILDING VOID

As specified in the regulation (Building Ordinance 1997a), buildings for habitation are required to provide windows with certain area to provide lighting and natural ventilation. In the old generation of domestic buildings, all rooms, including bathrooms and kitchens, are placed on the perimeter of the unit to comply with the legislative requirements. Some units are forced to face undesirable views, such as being unable to get a harbor view. It is not welcome by the industry and the users, so in the newer developments, the service rooms, bathrooms and kitchens are placed inside the floor area to introduce maximum view and daylight into the living area.

In the existing building design in Hong Kong, as shown in Figure 1a, Units D and E might be 30 % cheaper than units A and H. Not only that, kitchens and bathrooms are placed on the building perimeter. Bedrooms in units A are placed adjacent to rooms in units H, curtains have to be drawn down to get privacy. A new trend in the flat layout is to have the units placed side by side as in Figure 1b. Internal voids where bathrooms and kitchens of every unit are opened to are found in order to comply with the requirement. But there are concerns on fire safety. When there is fire in an apartment, smoke flowing out of the room (say a kitchen) to the internal void might spread from the fire level to the adjacent levels.



(a) Old design (b) New design with internal building void

Figure 1 New Architectural Features

At least three points should be considered for fire safety:

- Fire in a room adjacent to the internal void

Likelihood of flashover can be assessed by the equation on the minimum heat release rate Q_{mf} (in kW) causing flashover proposed by Thomas (1981) for a small shop of length L (in m), width W (in m), and height H (in m); and for an opening of area A_v (in m^2) and height H_v (in m):

$$Q_{mf} = 378 A_v \sqrt{H_v} + 7.82 \{[LW + (L + W) H] - A_V\} \quad (2)$$

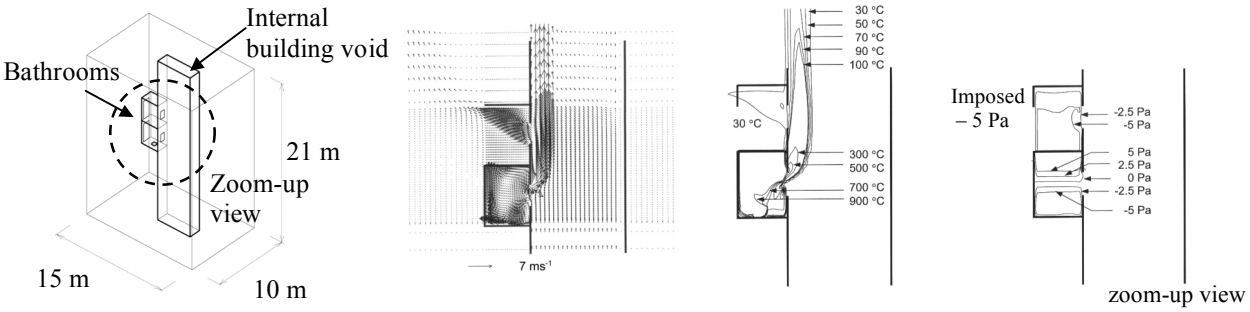
For a bathroom of typical size, the required heat release rate to cause flashover is only 0.5 MW! It is easy to find combustible materials and products in a bathroom or kitchen burning with heat release rate higher than 0.5 MW!

- Spread of smoke from the fire room to adjacent levels

Smoke spreading is dependent on the air flow. Natural driving forces of air flow in the internal void are stack effect; wind-induced action; and buoyancy of hot smoke. Computational Fluid Dynamics (CFD) can be applied to study spreading of smoke and flame from the fire room to adjacent levels through the internal void. The dimension of the void, wind effect, mechanical ventilation system operated and whether a flashover stage is reached in the fire room would vary the severity of the hazard. Full-scale burning tests are recommended to carry out in order to verify the results of the simulation.

An example is taken on simulating smoke spreading to an internal building void for a bathroom. The bathroom is of length 2.3 m, width 1.5 m and height 3 m. There is a window of width 0.6 m and height 1 m located at 1 m above the floor of the fire room. The internal building void is of width 4.6 m and length 1.5 m. An internal void section of 21 m high is considered, with the fire room at the third level, i.e. 9 m above the ground level as in Figure 2. A fire of heat release rate 300 kW less than the minimum value for flashover is considered. A fire occurring on the third level was simulated with the CFD simulator PHOENICS (CHAM 2000). There is a pressure difference of -5 Pa at the door of another bathroom at an upper level above the fire room with the window opened.

Results of the simulation are shown in Figure 2. It is observed that hot smoke from the fire room would move up the internal void and spread to the adjacent upper levels. When there is a differential pressure across the door of room just above the fire room, say at -5 Pa, due to other effect, the upper level would be affected. Hot smoke, or even flame would spread to the level above the fire room and even to the other parts of the upper level apartment.



(a) Geometry (b) Velocity vectors (c) Temperature (d) Differential pressure

Figure 2 CFD simulation

- Fire resistance for windows

It is unlikely to use fire-rated glass as the glazing material. Therefore, there is high risk of smoke and fire spreading to adjacent levels. Full-scale burning tests should be carried out on apartments to justify the design, and verify the numerical works. The PolyU/USTC Atrium (e.g. Chow et al. 2001) is a good site for the experimental studies. Other factors such as fire spreading over the finishes had not been considered, there would be flame spreading even over paint surfaces (e.g. Murrell 1998)!

6. POTENTIAL HAZARD ASSOCIATED WITH THESE FEATURES

As discussed before, the new architectural features are able to save the non-renewable energy and maintain a healthy natural environment. It is beneficial in terms of the environmental aspect. However, it may be harmful in some other areas. Studies should be carried out carefully in order to protect public safety.

Window openings are used to introduce natural ventilation. Wind action outside a building would generate pressure difference across the building envelop. When there is a fire inside one of the stories, the opened windows would create a pathway for spreading of smoke while they are contributed to the air exchange on a safe day. A negative pressure may probably be generated on the leeward side of the building. Flame and smoke would then spread out through the windows easily and to the other stories and buildings.

Though glass is a non-combustible material, it will be weakened when heated up to its maximum operating temperature. Toughened glass may be able to endure higher temperature, but it is fragile after exceeding its critical limit. When it is heated up to about 295 °C, cracking may easily happen during this stage (Glass and Glazing Federation 1978). Moreover, as a poor conductor, heat is difficult to transfer on a glass pane from the area exposed to the fire to the other region. The temperature difference between these hot and cool regions will induce thermal expansion. When tensile stress reaches its critical value, cracking will occur (Hassani et al. 1994-95). The aluminum framework of windows, even more frail than glass, will be weakened when heated up to 200 °C and melted at about 550 °C. Its severe distortion may induce stresses across the glass plate being held up by the frame, and even worse, the whole piece of glass will fall out (Loss Prevention Council 1999).

It is also the case for the full-height glass tower. A case was demonstrated years ago where the glass panes fell off the wall of an office building. It was not caused by a fire, but by a typhoon. It indicated that a number of potential risks are associated with a glazed building. Attention should also be paid to the ability to resist wind load.

7. CONCLUSIONS

Natural environment has been damaged by the extensive use of energy and natural resources. Greenhouse gases emitted has led to the increase of the global temperature abnormally. Environmental conservation is a nationwide issue in the new century. Efforts are already put into the development of green features in the construction projects, like most of the large-scale development and the government buildings as mentioned before. Their contributions in reducing energy consumption can be ensured. However, attention should be paid to their drawbacks in the other aspects, especially those affecting public safety. Further studies should be carried out to investigate the constraints of these architectural designs. Full-scale burning tests may be used whenever necessary. Designs should be enhanced by providing

safety or some protection measures, such as adequate fire resistance period FRP, to achieve environmental targets.

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Integration of a Symbiotic Living Construction - A High Efficient Recycling System

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1. INTRODUCTION

Global shortage of energy supply and damage of living environment are two major concerns for human sustainable development. An efficient and cyclical usage of resources in a limited area is a key determinant of sustainability. Thus, developing a high efficiency circulatory system to mitigate the burden on our environment is important in sustainable development. Symbiosis, a phenomenon that two or more organisms live on a base of mutual benefit, is a sustainable model of the nature. To integrate the philosophy of our mother nature into a construction, we have designed a symbiotic living construction in subtropical area based on food chain and resources recycling. The system comprises many new features including the food supply system, dry toilets system, greywater recycling and composting systems. Furthermore, several menus based on the nutritional requirement for healthy living and vegetables that are grown on the planting system were designed. The food supply system not only provides fresh vegetables but also reduces the indoor temperature by transpiration through the leaf surface. Reduction of indoor temperature lowers the requirement of air condition and greatly reduces the energy consumption as well as prevents the sick building syndrome. The water recycling system helped to remedy greywater into water for irrigation of crops and for aquaculture purpose. The dry toilet and composting systems converted human feces into fertilizer for the food supply system. To evaluate the efficiency of recycling, the total input and output of materials through the system have been recorded. Furthermore, several biological and physical parameters have been monitored to assure the safety of the system. Our preliminary results indicated that it is possible that a healthy sustainable building could also be biological sustainable if sufficient agriculture area is provided for the recycling of the food using solar energy as a sole source of energy supply.

2. MAIN GOALS

A system based on food chain and resource-recycle using maximized solar energy was designed for subtropical area in northern Taiwan. The purpose of the study was to design a symbiotic living construction with highly biological efficiency to meet possible shortage of fossil energy in the coming future. The system was aimed to reduce total energy requirement

to at least 50% of energy consumption that is needed to support the way of living in current building to meet a changing circumstances of global shortage of energy supply. It is also important concept to solve the problems associated with living environment by biological methods in separate small symbiotic community instead of a sophisticated urbane system (Fig.1).

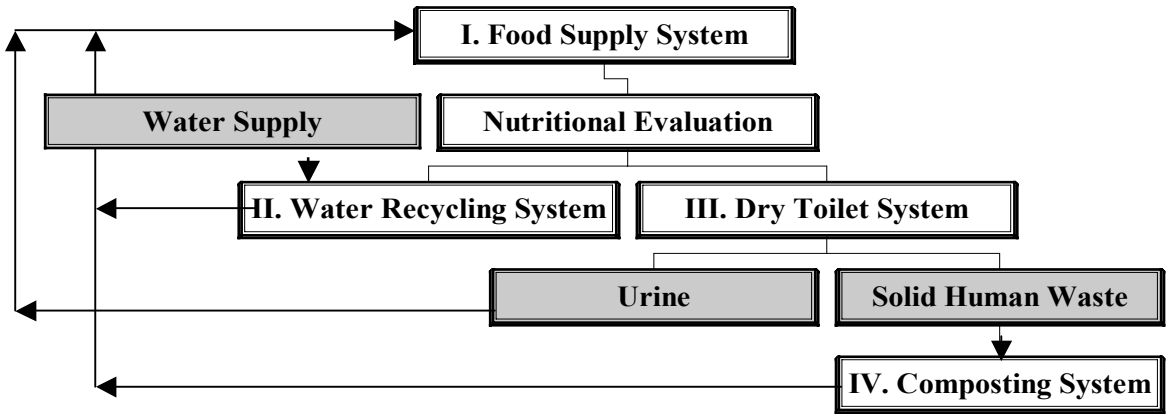

Figure 1 The concept of a symbiotic system: To recycle starts with the food from the food supply system (I) that also plays a role in reduction of temperature through transpiration. The human waste goes to a dry toilet system (II) or urine reservoir. Greywater is collected and treated by a cleaning system outdoors (III) and then deposited in pool for aquaculture as well as the water supply of the food supply system. The diluted urine is pumped for crops in the near-by garden. The dried human waste together with the additional peat is converted into fertilizer by composting (IV).

2.1 The Food Supply System

To meet the nutritional requirement for healthy living, selected crops were calculated for their nutrition value and photosynthetic efficiency to ensure sufficient food supply in quantity and quality. To enhance productivity of the crops in limiting land area, a unique vertical planting system was constructed to surround the south, east and west walls of the building. The vertical planting system also reduced the heat of the building caused by sunshine as well as to reduce heat through transpiration of leaf area of the crops.

2.2 The Nutritional Evaluation

We have estimated the nutritional requirements of human including carbohydrate, protein, minerals, vitamins, and lipid to support healthy activity and condition. The data was compared with those obtained from RDNA (Recommended Daily Nutrient Allowance, Ministry of Health, Taiwan, 1996). Our preliminary results indicated that it is possible that the vertical planting tower produces enough fresh vegetables for the inhabitants. However, main calorie foods such as wheat and rice need to be supplied to meet the requirement of RDNA.

2.3 The Dry Toilet

The dry-composting toilet, which use neither water nor sewage facility, have been developed and become increasing popular. Human wastes in the symbiotic system were considered as a valuable resource for recycling. Dry toilet system (Sun-Mar Compact, Sun-Mar Co. U.S.A.) was employed and the waste including feces and urine combined with the applied peat was treated in the toilet system at 60°C under ventilation for at least 4 months. The dried powder-like residue of human waste was analyzed for its microbial flora, nitrogen, potassium and

phosphorus as well as trace mineral elements to evaluate the safety and feasibility for fertilizer. Given the fecal coliform bacteria can be detected in fertilizer obtain from dry-composting toilet (Redlinger et al., 2001), the safety of dry toilet have been further evaluated. Although our data revealed that the gene-tagged E.coli were not detected in the biosolid waste sample, we combined human waste, kitchen and garden residues and then the matured compost was used for the crops again. Microorganisms involved in the treatments of human waste and composting were analyzed for further application.

2.4 Water Recycling System

Blackwater and greywater (wastewater without toilet) do have different characteristics (Otterpohl, 2002). In our system, the blackwater recycling system is not necessary because of the use of dry toilet. Water recycling system was layout to recover greywater into agriculture purposes including irrigation of crops and aquaculture.

2.5 Composting System

We have also developed a residual food-composting chamber to recycle the residual foods. Biological and physical parameters including the consumption of food, nutrition value of food, quantity of human waste, health condition, productivity of crops, efficiency of photosynthesis, microbiota, turnover rate of compost, and water consumption were measured. The total input and output of the materials in this system were also monitored. The volunteered individuals stayed in the symbiotic system were studied for social and psychological adjustment.

3. SUMMARY OF RESULTS

1. We suggested a modified nutrition requirement for a daily allowance for the system and over selected 30 crops including vegetables, fruits and aquaculture products to provide sufficient nutrients for carbohydrates, protein, minerals, lipids and vitamins.
2. Preliminary study for the recycling system has proven that the dried human waste from system was found to be able to eliminate the gene-tagged E coli after a six months treatment in the relative high temperature ($60^{o}C$) and suggested to be digested by thermopiles microorganisms. The minerals in the dried waste contained 0.33%, 0.0064% and 3.1% of nitrogen, potassium and phosphorus, respectively. Trace elements included copper, magnesium, iron and manganese at concentrations of 5.15 ppm, 1291.48 ppm, 126.13 ppm and 87.69 ppm, respectively. Heavy metals such as mercury and lead were not detectable. The total volume of the waste reduced to 5 to 10% of in respect to that of feces and urine with the addition of peat.
3. The photosynthesis rate of the selected crops was found to be only 0.3% in average and it is estimated that at least $102m^2$ land area is required for each individual adult in northern Taiwan to supply adequate food with sufficient nutrients for health.

4. CONCLUSIONS AND RECOMMENDATIONS

The concept of symbiotic arisen from two or more organisms living on a base of mutual benefit. In the present study, we explore the possibility of whether human can live with limited organisms in a symbiotic construction with high efficiency of recycling. It is very possible that people live in this system will encounter a tough live when everyone needs to operate the symbiotic system to obtain food for the daily requirement. However, to pursue a healthier and sustainable living condition, it will be worthy to develop a new model of living that can reduce energy and material input to our living system, particularly when fossil energy source become scarce. Our preliminary results suggest that it is possible to integrate the

concept of symbiosis into a sustainable building if sufficient agriculture area is provided for the recycling of the food using solar energy as a sole source of energy supply.

Taiwan is an island located in the subtropical area characterized with high temperature and high relative humidity, and it is difficult to cool down air temperature when the humidity is high. Air conditioner is widely used in Taiwan to reduce room temperature as well as humidity. Given air conditioner is associated with sick building syndrome and consume a lot of energy, other resolutions have to be explored. Obviously, it is an effective solution to remove heat by transpiration through leaf surface of the crop in the vertical planting system. Indeed, our preliminary data revealed that the vertical planting system greatly reduced the heat of the building by shielding and by transpiration of leaf area of the crops. Reduction of heat is an important issue in subtropical area and should be taken into account in designing a sustainable living environment in this area.

Conversion of human wastes into fertilizer for growing the crops could be carried out by the dry toilet system that turned feces and urine into an easy to handle, clean and dried powder without pathogenic consideration. Plants and animals as well as microorganisms involved in a symbiotic system will be evaluated for a real living style. An experiment center designed to accommodate 24 individuals for the symbiotic system located in Northern Taiwan will be completed in mid-2002. Upon completion of the experiment center, we will be able to estimate the recycling efficiency and to assess the performance using the commercial available environmental assessment tools. We will combine these estimates and variables to determine the cost-effectiveness of this system.

5. ACKNOWLEDGEMENT

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Use of recycled concrete as aggregate in normal concrete in Norway

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INTRODUCTION

It has been estimated that approximately 50 million tons of concrete are currently demolished each year in the European Economic Communities and about 1 million tons are demolished in Norway according to Mehus et al. (2000).

For environmental and political reasons the number of readily accessible disposal sites around major cities in Norway are decreasing and have been restricted. For these reasons reuse of demolished concrete as aggregates for production of new concrete have been investigated both in the laboratory and in the field.

The utilization of by-products and secondary materials in normal construction concrete is influenced by economic factors like costs of transportation and the price of the alternative materials. The economic factors are estimated based on experience from a parking house and a school building in Oslo.

The quality of the recycled aggregate were investigated as well as the mechanical properties of recycled aggregate concrete with increasing amounts of recycled concrete aggregate. This involves both extended laboratory testing and long-term follow-up studies of existing full-scale demonstration projects.

RESIBA

RESIBA – Recycled Aggregates for Construction and Building is an EcoBuild project, which aims to make recycled aggregates a competitive product for a range of applications (http://www.byggforsk.no/Prosjekter/RESIBA/english/default.htm). The main objective of the RESIBA-project is to encourage long-term use of recycled aggregates for various applications within the Norwegian building and construction industry, thus reducing the impact for the industry on the environment. This article is based on the work of Work package 2: Demonstration projects, which aim is to evaluate the use of recycled aggregate in already completed construction projects as well as to launch pilot projects investigating the use of recycled aggregates in different types of concrete structures, roads and trenches. Main results are given in Lahus et al 2002.

USE OF RECYCLED AGGREGATE

Recycled aggregates

1.5 million tons of heavy building waste is produced in Norway each year (Statistics Norway ,1999a). About 2/3 of this consists of concrete and bricks (Figure 1). For comparison, about 6 million tons of natural aggregates is produced in Norway each year. Concrete and brick waste can be crushed and used on site or delivered for recovery of materials to specialized recycling plants and some crushed stone producers. But there are only a handful of specialized recycling plants in Norway that handle concrete and brick waste. In 1999, these plants recovered approx. 130 000 tones of concrete and brick (Statistics Norway ,1999b). Increasingly, concrete from demolished buildings is being crushed using mobile crushing machines and reused on site, for example, for landfill. The recycled aggregates may be used in structural concrete, sprayed concrete and building blocks.



Figure 1 After crushing and sieving the crushed concrete becomes useful recycled aggregates for concrete (Picture: Bente Lillestøl, Veidekke ASA)

Concrete

The yearly production of concrete in Norway is about 2 millions square meter, and 68 % of this consists of ordinary concrete quality C 35 NA with a characteristic compressive strengt og 35 MPa. According to Norwegian regulations (Norwegian Concrete Assosiation, 1999), 20 % of aggregate with D_{max} > 8 mm can be replaced by recycled concrete aggregate.



Figure 2 Production of concrete foundation with 20 % replacement of natural aggregates with D_{max} > 8 mm at the Fornebu Building site (Picture: Bente Lillestøl, Veidekke ASA)

During the construction of a new parking garage at Fornebu, the contractor incorporated the use of 20 % of recycled aggregates by replacing 20 % of the coarse aggregate in the concrete fundation (Figure 2). Concrete production and casting of the foundation were successful, and the laboratory test results showed that concrete met the material properties as specified (Lahus and Lillestøl, 2000). Both the production and use of recycled aggregate concrete satisfied the requirements set by both the estate developer and Norwegian concrete codes and Publication No. 26 from the Norwegian Concrete Association.

Laboratory testing of concrete quality C 35 and C 45 using up to 100 % recycled aggregates as a substitute for the coarse aggregate also yielded positive results (Lahus and Lillestøl, 2000a and Lahus and Lillestøl, 2000b). The mix designs are given in Table 1 and 2.

Table 1 Mix design concrete quality C 35

Material		Supplyer	C35 NA Lab	C35 NA Lab-20R	C35 NA Lab-40R	C35 NA Lab-60R	C35 NA Lab-80R	C35 NA Lab-100R
Fine agg. 0-8	kg/m^3	Norstone AS, Årdal	939	939	939	939	939	939
Coars agg. 8-11	kg/m^3	Norstone AS, Årdal	347	347	347	174	0	0
Coars agg. 11-16	kg/m^3	Norstone AS, Årdal	347	174	0	0	0	0
Coars agg. 16-25	kg/m^3	Norstone AS, Årdal	173	173	173	173	173	0
Recy. Coars agg.. 10-20	kg/m^3	BA Gjenvinning	0	173	347	520	694	867
Sement	kg/m^3	Embra Standard	319	319	319	319	319	319
Silica	kg/m^3	Elkem Silica	20	20	20	20	20	20
Scancem P	kg/m^3	Scancem	2	2	2	2	2	2
Scanflyt-2	kg/m^3	Scancem	2	2	2	2	2	2
Water	kg/m^3		192	192	192	192	192	192
Effective v/c+s			0,6	0,6	0,6	0,6	0,6	0,6

Table 2 Mix design concrete quality C 45

Material		Supplyer	C45 NA	C45 NA-20R	C45 NA-40R	C45 NA-60R	C45 NA-100R
Sand 0-8 mm	kg/m^3	Storsand	894	894	894	894	894
Pukk 8-22 mm	kg/m^3	Storsand	952	762	571	381	0
Resirk. 10-20 mm	kg/m^3	BA Gjenvinning	0	190	381	571	952
Sement	kg/m^3	Embra Standard	319	319	319	319	319
Silica	kg/m^3	Elkem Silica	20	20	20	20	20
BV40	kg/m^3	Sika	1,7	1,7	1,7	1,7	1,7
ECO2	kg/m^3	Sika	2,7	2,7	2,7	2,7	2,7
Water	kg/m^3	Kommunalt	176	176	176	176	176
Effectivt v/c+s [1)]			0,52	0,52	0,52	0,52	0,52

The mean compressive strength after 28 days were reduced down to between 85 and 90 % with 100 % recycled aggregates as a substitute for the coarse aggregate (Figure 3)

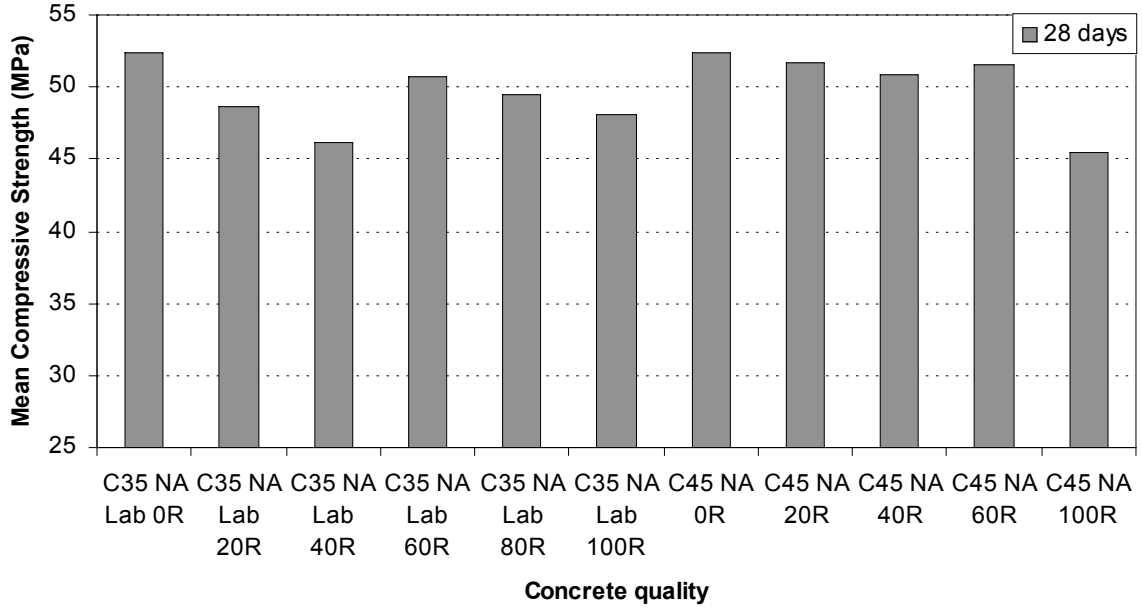

Figure 3 Mean compressive strength with increasing replacement of natural coarse aggregate at the Fornebu Building site (Picture: Bente Lillestøl, Veidekke ASA)

Shotcrete

Recycled fine aggregate (0-4 mm) were for the first time introduced in sprayed concrete with satifactory results (Figure 4) as reported by Farstad and Hauck (2001). This world's first employment of shotcrete incorporating recycled aggregates can be found at Oslo Sporveier's new tramline over Gaustadbekkdalen in Oslo were completed in 1999. The vertical sides of an EPS lightweight fill were protected by 100 m^2 shotcrete were up to 20 % of the sand was substituted by recycled aggregates according to Hauck and Farstad (2001). The contractor successfully conducted the spraying and the shotcrete met the material properties as specified. Both the properties of the fresh shotcrete and the mechanical properties were satisfactory as well as the durability characteristics. The compressive strength was reduced by 18 % with use of 20 % recycled aggregate.

Building blocks

Masonry sound insulation building blocks were produced using 30 % recycled aggregated 4-10 mm. Laboratory testing demonstrated that the results were satisfactory and in accordance with the technical spesifications (Figure 5). The marked will decide if further production will be initiated.



Figure 4 Sprayed concrete with recycled aggregates (0-4 mm) at the Gaustabekk Building site (Picture: Bente Lillestøl, Veidekke ASA)



Figure 5 Building blocks with 30 % recycled aggregates (0-4 mm) (Picture: Bente Lillestøl, Veidekke ASA)

COSTS

Recycled aggregates are moderate and the unit cost is typical 60-90 % of natural aggregates. According to economical estimates, use of recycled aggregates vs. natural aggregates in concrete, shotcrete and building block does not increase the material costs in the evaluated projects.

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Polymeric Materials in Sustainable Building

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1 INTRODUCTION

Material design and waste management have more and more important role in building and construction planning phase nowadays. Polymeric materials have increasingly appeared in materials waste from the demolished buildings [1]. Increased use without consideration of waste problems was a usual procedure before the debate about recycling started. In recent years interest in recycling of different materials has increased due to different environmental aspects. Buildings constructed in Sweden in the 1960s and 1970s, which are now gradually being demolished, have been investigated in this project in respect of the potential for recycling of polymeric materials. One of the most important tasks in selection of suitable options of handling of plastic waste is to determine the technical quality and the remaining lifetime of collected materials, which is also included in this work. The final goal of the project is to give recommendations on how to take care of polymeric materials in accordance with the eco-cycle system and to get knowledge about the choice of materials and construction solutions in the future. The result of this project will be a topical question to people that work with choice and design of materials for buildings. This investigation is a puzzle piece of a subprogram that will determine the role of sustainable materials and components and theirs recycling in sustainable buildings [2].

2 PROJECT ACCOUNT

Three residential houses and polymeric materials from there were examined. The project started with an inventory part, which governed the other parts and formed the project as a case study. The investigation was meant to serve as a mapping of where and in what quantities the polymeric products are to be found and furthermore to give information regarding the possibilities to dismantle them [3]. A great number of polymeric products from the houses have been collected. After characterisation and identification of technical quality of the collected materials the study was concentrated on some selected materials with the best potential for recycling. PVC (Poly Vinyl Chloride) was the most dominant plastic being used both in plasticised and rigid form in many different applications such as cables, pipes, profiles, floorings, ect.

PVC cables have been studied in the second part of the project. Cables remaining desirable properties and potential for recycling have been investigated by determination of tensile properties and measuring concentrations of different additives such as stabilisers, plasticisers and filer using residual stability, SFE (Supercritical Fluid Extraction) and TGA (Thermo Gravimetric Analysis) methods [4].

The third part included indoor profiles. In this part of investigation, new profiles made of rigid PVC have been studied after various numbers of repeated extrusions in order to gain knowledge about the changes of properties and durability after conventional processing and ageing during service time. New indoor profiles of PVC were re-extruded, from one to five times without adding new stabilisers. Dehydrochlorination and mechano-chemical

degradation, the most important reactions during processing, lead to the formation of labile sites on the PVC molecules. As such sites act as starting points for further degradation processes, it was important to investigate how repeated extrusion influenced the long-term properties of the material. The material was characterised after each extrusion using measurements of colour, degree of gelation, elongation at break and FTIR (Fourier Transform Infrared Spectroscopy) and UV-VIS-NIR spectroscopy. The durability of the material was evaluated by means of accelerated ageing [5] in ventilated heat ovens [6]. Dehydrochlorination and colour change due to formation of polyene sequences have been measured.

Old flooring materials, three made of PVC and one of linoleum, have been examined in the current work that is the forth parts of this study. The content of plasticisers and fillers, the residual stability and the heat values from the energy recovery have been determined. Newly manufactured PVC floorings of two types, homogeneous and foamed heterogeneous have been aged in air at 80 °C. Before and after the accelerated ageing the content of plasticiser, the residual stability and the heat values have been determined. Some complementary analyses have also been made, such as tensile tests and determination of volatile decomposition products.

2 EXPERIMENTAL

2.1 Material

In the first part of this study, more than twenty-seven products were collected from the old houses for subsequent investigation of technical quality and remaining lifetime, which will be used as a basis for determination of the feasibility for mechanical recycling of the materials and for classification of different materials for various handling options. The type and quantity of polymeric products have been mapped for each residential house and the materials were evaluated with respect to the degree of cleanliness and difficulty to dismantle them. The products have also been measured and weighed and the total amount of them in the houses was calculated based on the construction drawings. In the part two, three and four of this study, plasticized and rigid PVC were investigated. The plasticized PVC products were cables and flooring materials and the rigid PVC products were indoors profiles. The old or natural aged PVC products were collected from the old houses while the new products were manufactured using similar to the old products recipes, with exception of stabiliser, which is now a combination of Ca/Zn instead of lead.

2.1.1 Cables. About 50 different cables and sheathings made of plasticized PVC were collected from the old buildings. Cables of different diameters, colours and thickness were found in the old houses inside protective pipes or inside or along walls with or without sheathing. Some cables were assembled in intermediate filling and outer sheathing. For comparison a model PVC material was used containing equivalent proportion of the plasticizer.

2.1.2 Profiles. Both new and old collected PVC profiles were investigated. The material for new profiles was granulates of suspension PVC stabilised with calcium/zinc. This material was of standard quality for production of white, rigid profiles for indoor applications. After each extrusion, some of the manufactured profiles were saved for further investigation, and the rest was cut into about 6-mm^2 pieces. The ground material was used for the extrusion of the next generation of profiles. The indoor PVC profiles were re-extruded up to five times, without adding any new stabiliser, or any other additives. The old PVC profiles with lead

stabiliser were re-extruded after collection, some being saved as reference for further investigations.

2.1.3 Flooring materials. Both new and old collected PVC floorings were investigated. The new material was made in Sweden the same year that investigation took place. One of the new flooring materials (homogenous flooring material) was made of installation waste year 2000.

2.2 Estimation of the difficulty in dismantling and the degree of cleanliness

Selective demolition of buildings is necessary if materials are to be recycled. Sorting and separation are therefore performed, normally by eye and by hand, using simple tools. In order to include the cost factors, it is important to estimate the number of working hours in relation to the type and amount of the material demolished and the need for special or advanced tools. For this reason, a scale for estimation of the difficulty of demolition and sorting is defined here. The scale consists of four levels as described in Table 1.

TABLE 1 - Difficulty levels of demolition

Difficulty level	Working hours	Working tools
1	less than 10 minutes	no tools
2	less than 75 minutes	simple tools
3	less than 150 minutes	simple tools
4	not possible or not worth while	-

A conglomeration of often tightly bonded materials is often found even when selective demolition is used. It is necessary to separate and sort materials during demolition in order to collect materials as clean as possible, but even so, additional sorting, separation and purification are often necessary at the factory before re-melting. The cleanliness of the polymeric products is an important piece of information, which is included here using a special scale. The scale consists of four levels as described in Table 2.

TABLE 2 - Cleanliness levels

Cleanliness level	Contamination	Purification procedure needed
1	no contamination	-
2	slight contamination	simple
3	slight contamination	advanced
4	heavy contamination	not possible or not worth while

2.3 Accelerated ageing

The quality of a durability prediction is closely related to the accuracy of the environmental simulation performed in the test. For some materials, it is of great importance to take into consideration also transport processes such as diffusion and evaporation/desorption from the surfaces, as in the case of plasticizers and stabilizers. The acceleration was achieved by an increase in temperature using the assumption that the degradation mechanisms can be described by a simple model given by the Arrhenius equation.

Cables: Mechanically unstressed model material was aged at different temperatures in heat cabinets with laminar airflow.
Indoor profiles: Mechanically unstressed pieces of profiles that were extruded from one to five times were aged at different temperatures in ventilated heat cabinets having laminar airflow. The ageing temperatures were chosen below the PVC glass transition temperature (Tg), which is close to 80 °C.
Flooring materials: The accelerated ageing of PVC floorings was designed to simulate extreme conditions caused by the alkaline environment caused by moist concrete. The ageing of PVC floorings has an influence on the possibilities of mechanical recycling but can also have effect on the heat value since the plasticiser content of PVC is a very important factor. Earlier studies of accelerated ageing in air of plasticised PVC at relatively low temperatures (70 – 110 ºC) indicated that under these conditions the loss of plasticiser by evaporation is the main degradation process [3, 6].

2.4 Measurements

Tensile tests were performed at standard atmosphere (23 °C and 50 % RH) using a universal testing machine with a constant rate of crosshead movement. Elongation at break was determined for the materials before and after various exposures.

Concentration of active stabiliser in the model material, cables, indoor profiles and flooring materials was evaluated using measurements of residual stability expressed as stability time t_s, which is defined as the time when the evolved hydrogen chloride is observed.

Extraction with SFE was used to determine the amount of plasticiser in the model material, cables, indoors profiles and flooring samples. Previously, it has been shown that SFE is an appropriate method for such analysis [4].

The effects of ageing at molecular level were observed using spectroscopy measurements. The double bonds formed that are conjugated in polyene sequences longer than 6, were measured on the surface of profiles using UV- VIS- NIR spectroscopy. Identification of the plasticizer was performed, and its depletion followed by FTIR-measurements using an attenuated total reflectance (ATR) attachment.

RESULTS AND DISCUSSION

The three buildings studied are regarded as representative for the type and time period, showing an increasing use of polymeric products in Sweden. The oldest one contained very little polymeric products except floorings, which were heavily degraded. In the other two buildings, profiles, doorframes, pipes, cables and conduits seemed to be the most suitable products for recycling. Plastic floorings constituted the largest part in all objects but the purity and the technical quality of the materials was poor. Dismantling of most products takes 10 min. to 1 hour per flat using simple tools. In most cases, materials were contaminated and to achieve pure materials suitable for recycling, additional simple or advanced separation and purification procedures are needed before processing. One inconvenience in collecting and sorting of products constitutes of changes, which occur during service life. Some products are exchange once or several times and some materials are used in a very troublesome way (i.a. PVC-flooring glued on linoleum flooring). It is generally not possible to conclude technical quality or remaining lifetime of collected materials without testing.

Investigation of the potential for mechanical recycling of PVC cables has been based on a model material, which had a similar recipe as the old cables. Accelerated ageing of the model material was performed in air and in a nitrogen atmosphere at relatively low temperatures. The mass loss, as well as the consumption of the stabilizer seems to be independent of the

presence of oxygen. The activation energies were determined to be about 98-99 kJ/mole for the mass loss in air and in nitrogen, and about 101-104 kJ/mole for the stabilizer consumption. The results indicated that the mass loss is the dominant process in ageing of plasticised PVC at low temperatures. Cables and sheathings collected from the old buildings were tested and showed little change in elongation at break even after 34 years of use compared to the reference values. In addition, the measurements of residual stability show high values, indicating good thermal stability of the old materials. Some old materials were also subjected to the accelerated ageing in air at 80 °C for 2 and 4 weeks in order to evaluate the remaining lifetime of the insulation materials. Accelerated ageing of the old cables and sheathings corresponding to 44 years of natural life did not significantly affect the tensile properties of the materials. The maximum change that was observed in the content of extractable matter after ageing was 1 %. The investigation has consequently shown that the technical quality and remaining lifetime of collected old cables and sheathings are very good, making them suitable for reuse or mechanical recycling [4].

Profiles made of rigid PVC have been studied after various numbers of repeated extrusions in order to gain knowledge about the changes of properties and durability after conventional processing. The results have shown that rigid PVC can be extruded up to 5 times with satisfactory results, without adding any new additives. The yellowing exceeded the manufacturer's limit after the third extrusion but it should be possible to improve this by optimisation of processing parameters. Rigid PVC undergoes dehydrochlorination process [9] in dark even at low temperatures (below T_g). Activation energies at low temperatures decrease with increasing number of extrusions depending on increasing amount of chain defects. Activation energies for the degradation at low temperatures are significantly higher than corresponding value at high temperatures which means that accelerated ageing at high temperatures can not be used for the estimation of durability at low temperatures.

The lifetime was calculated using following equation: $t_w = t_e \cdot \exp[E_a/R \cdot (1/T_w - 1/T_e)]$
where t_w is the calculated lifetime, t_e is the lifetime at elevated temperature, T_w and T_e are "in use" and elevated temperature respectively and E_a is the activation energy. It is obvious that the value of E_a and the temperature difference has a crucial importance for the calculated lifetime.

Table 2. Activation energy and calculated lifetime.

Material after:	**Activation energy** [kJ/mole]	**Calculated lifetime** [Years]
1st extrusion	127,9	142
2nd extrusion	123,2	124
3rd extrusion	120,9	110
4th extrusion	118,8	106
5th extrusion	99,3	47

The mechanical properties of the collected products have changed insignificantly after 20-25 years of service life. Mechanical recycling should be quite possible for rigid PVC provided that contaminants are taken away from the material [5].

The ageing process of plasticised PVC includes several different causes of event. Processes in plasticised PVC accelerated by increasing temperature are evaporation and migration of additives, mostly plasticiser, both from and within the PVC matrix. Another process is decomposition of both additives and the PVC resin itself. Dehydrochlorination of PVC occurs especially at high temperatures, causing unsaturations in the PVC. Other influences important for the ageing processes of PVC flooring can be possible migration of plasticiser from the flooring material into the flooring glue and decomposition of plasticiser caused by the alkali from fresh concrete.

The analyses made of the different PVC floorings showed that most of the stabilisers and plasticisers were left even if the floorings had been aged during extreme conditions. After accelerated ageing of PVC floorings on concrete 2-ethyl-1-hexanol, a common plasticiser decomposition product, was detected both by the significant smell and analyses with GCMS. Nevertheless the loss of plasticiser proved to be small during all the conditions used in the study. It is shown that decomposition of plasticiser can be an indoor environmental problem but is a small problem concerning the properties of old PVC flooring. The tensile tests of the homogeneous flooring before and after accelerated ageing confirmed that conclusion since no significant changes in the tensile strength could be detected.
All the tested PVC floorings have retained most of their properties, which indicates a possibility to mechanically recycle post-consumer PVC flooring and consider the recyclate to be a high-quality product. The heat values of the PVC floorings were shown to be dependent on the content of plasticisers and fillers and consequently almost completely independent of the ageing time. The heat values of the different floorings were determined to be between 15 and 21 MJ/kg.

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osModell Kronsberg - Sustainable Building for the Future

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1. GENERAL INTRODUCTION

Lying to the southeast of the city of Hannover, Kronsberg is the largest homogenous area for building development in the state capital of Lower Saxony. Various urban development concepts had been proposed since the 1960s, but it was the World Exposition that enabled the municipality to implement them. The Kronsberg development was itself a World Exposition exhibit, addressing the EXPO 2000 themes of 'Humankind – Nature – Technology' through its exemplary vision and design quality.

By the year 2000 almost 3,000 dwellings had been built, and the final plan foresees a total of 6,000 homes for 15,000 people. Three children's day centres, a primary school, a district arts and community centre, a health centre and shopping centre are in operation, all built to high ecological standards. Post-utilisation of the World Exposition grounds will develop extensive commercial areas; by the end of 2000 around 2,500 jobs had located next to the new residential area.



Figure 1 Primary school

2. CONSTRUCTION PRAXIS

The Kronsberg city district was built applying all the most modern expertise on ecological construction and habitation in the spirit of Agenda 21. Ecological objectives had overriding priority in planning and constructing the district; urban planning targets of space-saving development layout, environmentally friendly transport, good open spaces and the proximity of homes and jobs were consistently pursued.

On Kronsberg there was a deliberate decision not to engage a single major property developer. Instead, homes were built by around 30 different housing developers and project managers with very varied concepts. Their projects evolved in detailed consultation with the municipality. This 'cooperative planning procedure' was headed by a specialist department within the City's Planning division (J/2000). The City administration was in its turn supported by a planning advisory board.

3. ECOLOGICAL CONSIDERATIONS

On environmental issues, the municipality's environmental planning group for the World Exposition, K/2000, was given the task of drawing up very high standards for soil management, water management, and waste and energy policies, and guiding and monitoring their applications throughout the construction phase.

A special 'Kronsberg Standard' was devised for all residential and commercial buildings and open spaces, applied to the entire district and incorporated in land sale contracts, development plans and other regulations. All stakeholders thus had to meet high expectations in their planning and construction processes.

The City of Hannover's 'Ecological Optimisation at Kronsberg' project was recognised as one of the Expo 2000 decentral 'Projects around the World'. As well as the Expo Corporation, the German Environment Foundation and the European Union also contributed to funding for innovative projects.

In the front of planning and implementation, environmentally compatible energy provision systems were combined with environmentally sound construction and conservation of natural resources.
The project content was divided into:

- energy efficiency optimisation
- water management
- waste management
- soil management
- communications, skilling and qualification measures

4. ECOLOGICAL OPTIMISATION AT KRONSBERG

4.1 Energy efficiency optimisation

The central concern of energy efficiency optimisation at Kronsberg is to reduce CO_2 emissions by at least 60% compared to current standards for conventional residential buildings. Reduction of energy consumption is achieved through Low Energy House building methods with appropriate quality assurance measures, optimised energy provision by a differentiated district heating system fed by two decentral cogeneration plants, and specific economy measures on the consumer side.

A further 20% reduction in CO_2 emissions is achieved by integrating wind power projects (two wind turbines of 1.5 and 1.8 megawatts are erected at Kronsberg), the 'solarcity' solar power project with a superinsulated 2,750 m^3 seasonal storage tank and other innovative technology such as passive houses, photovoltaic plants at the primary school, the arts and community centre and the shopping centre, and a microclimate zone, where the inner courtyards are roofed with an extremely light double chamber transparent film, creating a stable, mild climate in the courtyard area.



Figure 2 Decentral cogeneration plant in residential block basement

4.2 Water management

Although the construction projects cover large areas of ground the balance of natural water resources on Kronsberg has been largely maintained using a newly-devised method of rainwater management. All precipitation on built-up and paved areas is absorbed, collected and gradually released. There have been no adverse effects on groundwater regeneration in nearby woodland, and water levels in the existing ditch system have remained constant.

On the public streets, rainwater is fed into the 'Mulden-Rigolen-System' soakaway trenches. On private open space, rainwater from roofs and paved areas is also collected and gradually released; in the residential areas it is often used as a design element to feed open ponds or watercourses.

Rainwater management has had a shaping influence on the design of the district and helped to create good quality open space. Making the theme of water visible has been a priority, to raise public awareness of the crucial importance of this element.

Equipping all apartments with water-saving taps has helped reduce water consumption. Residents are also encouraged to economise on drinking water by exhibitions and information material.



Figure 3 Open pond in residential area

4.3 Waste management

The aim of the Kronsberg waste management concept is to replace conventional waste disposal strategies with preventative waste management planning. Consistent waste avoidance and recycling was practised from the beginning of the planning and construction phases. Within the construction waste concept, the City of Hannover reached a contractual agreement with developers to use exclusively environmentally compatible and healthy building materials. For the construction phase, the City's Waste Management Service's 'low waste building sites' model project was devised to sort building waste on site. Recycling rates of around 80% were achieved.

The main component of the domestic and commercial waste concept is setting up innovative collection systems. Attractively designed containers close to the houses and pre-sorting bins in the apartments promote comprehensive waste separation. A grants programme supports home composting in the gardens.



Figure 4 Waste collection point

Under the motto 'reparieren statt deponieren' (mend it, don't dump it) there is a close-knit network of repair and alteration services at Kronsberg. An advisory service on opportunities for low-waste consumer habits, waste separation, and a composting programme intended for both residents and businesses, completes the services strategy.

4.4 Soil management

By 2000 around 700,000 m³ of soil had been excavated from the Kronsberg development. The central concern of the ecological soil management programme was to reuse these quantities within the district for landscaping and environmental enhancement. This rendered unnecessary the transportation of around 100,000 truckloads, thus reducing the dust, noise and exhaust fumes they would have caused. Disposal and transit costs for developers were considerably reduced.

The excavated soil was used to enhance and create typical local biotopes, to raise two viewpoint hills on Kronsberg and a noise buffer embankment alongside a nearby motorway,

to seal an old landfill rubbish tip, and for landscape enhancement around the World Exposition grounds.



Figure 5 Northern viewpoint

4.5 Kronsberg environmental liaison agency (KUKA)

KUKA GmbH was jointly founded by the City of Hannover and the 'Förderverein der KUKA e.V.' trust whose membership is made up of institutions closely concerned with the construction of the new district. Further funding comes from the German environmental foundation, 'Bundesstiftung Umwelt'.

'Environmental liaison' is the general term for a carefully devised range of communications instruments aimed at conveying an appreciation of the environmental consequences of actions, raising environmental awareness and offering possible courses of action motivating people to more environmentally-responsible behaviour. In this spirit KUKA monitors and promotes the ecological development of the Kronsberg sustainable city district in the areas of energy, waste, soil, water, landscape, farming and mobility. It is the lead agency for public relations work and presenting the projects, organises specialist conferences, and offers guided tours and information on the district with targeted publications. Working with five cooperation partners, KUKA devised a comprehensive skilling and qualification programme of ecological advisory and training measures for planners, craft workers, and residents of the new district.

5. EVALUATION

In the early summer of 2000 Hannover City Council commissioned a study to evaluate the first energy consumption data; collation and analysis of actual savings and energy flows in the Kronsberg district should show whether the projected 60% reduction in CO_2 emissions had been achieved. The 1999 database had proven to be of little use because of distortion by the need to dry out the new buildings, temporary heating supply measures, and uneven occupancy of apartments. By 2000 all components of the energy concept were in place. Projected savings for 2001 are in the region of 50% compared to the control sample. Taken as a whole, a combination of LEH construction methods and district heating from a cogeneration plant represents a highly efficient means of reducing CO_2 emissions.

6. TRANSFERABILITY

In planning and building the new Kronsberg district it has been possible to apply the main aims of ecological construction and integrate them in an overall concept. This was made easier by the financial preconditions created by its status as an EXPO 2000 project. While making allowances for the economic preconditions and consequences, the experience gained at Kronsberg can also be of use in other projects.

Additionally, the City of Hannover has prepared a briefing package to inform construction companies and developers in good time about instruments of ecological planning and construction. This ‘Info-Paket’, coupled with expert consultation, should be seen as a service aiming to integrate issues of energy, water, waste and soil, but also nature conservation, more strongly in future construction programmes.

Hannover's Kronsberg project has taken shape in close partnership and consultation with other European agencies and intiatives, particularly as regards innovative energy concepts. Partners include Parque Expo, Lisbon, ParcBIT, Mallorca, and Leidsche Rijn, Utrecht within the EU-THERMIE 'expocities' project, which promoted energy-saving initiatives exceeding the Kronsberg standard:

- ecological building materials with low embodied energy
- electricity-saving measures
- building technologies for the future
- integration of renewable energy sources and
- exhaust heat technology.

As the largest project, Hannover played a leading role in exchanges and consultations.

In 2001 Hannover took part in the 'Energy Saving Oscar' competition in Linz, Austria. As one of 1,260 entrants from 83 countries the Kronsberg settlement took second prize.



Figure 5 Kronsberg aerial view

ISO 14001 Benchmarks for Facility Management

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1. INTRODUCTION

The development and certification of Environmental Management Systems (EMS) to ISO14001 (ISO 1996a) has been promoted by some as being an essential element in the drive towards environmental sustainability. Advocates suggest that it can provide a comprehensive framework for significantly improving environmental performance, with substantial managerial, operational, and competitive benefits for those implementing the system. Critics contend that certification does not ensure either compliance with environmental legislation or continued performance improvements, and for some organisations and businesses obtaining an IS14001 certificate may merely be an image-building or public relations effort (Rondinelli et al 2000, Eroth et al 2000).

The contention is that organisations do not need an ISO certified EMS to meet the requirements of environmental legislation, or to improve environmental performance since ISO14001 certification of an EMS does not define or quantify environmental performance. Certification assumes that the EMS in place deals effectively with the organisations environmental impacts, implying that the organisation meets its regulatory obligations and will go beyond these requirements to achieve continuous improvements. However, absent from the process is an effective mechanism to verify the extent of improvements. Significantly, the defined objectives and targets in an EMS may be marginal, and could be well below potential. It is also noted that the standard focuses on outdoor environmental impacts and makes little reference to indoor environments, which is a matter of increasing concern for owners and operators of occupied buildings.

In Hong Kong's services dominated economy facilities such as commercial developments, comprising office towers, shopping malls, entertainment and recreational premises; large hotels with retail outlets; university campuses, private or public housing estates, etc, collectively have hugely significant environmental impacts. Most of these are high-rise and located in densely populated urban environments, and given the sub-tropical seasonal climate nearly all premises are air-conditioned, either from central plant or by individual units. Increasing affluence is matched by rising consumption of non-renewable resources.

As Hong Kong moves towards sustainable development (HKSAR Government 2000) there is increasing pressure to improve environmental performance. Some facility managers have taken action, such as conserving energy, reducing waste, and seeking certification under various voluntary 'green' certification schemes, but relatively few have established an ISO certified EMS. As of March 2002 of the 146 organisations known to have a registered EMS, only a dozen are involved in facility/property management, including 4 hotels (Environmental Protection Department 2002). Whilst many organisations are prepared to take steps to reduce

consumption, particularly energy, the cost (up to HK$500 000 for consultant fees) and time taken (9-12 months) makes the 'added value' of a certified EMS difficult to justify.

2. ISO 14000 STANDARDS

The ISO 14000 series of standards are being developed within the following key principles:

- they must result in better environmental management;
- they must be applicable in all nations;
- they should promote the broad interests of the public and the users of the standards;
- they should be cost effective, non-prescriptive, and flexible, to allow them to meet the differing needs of organizations of any size worldwide;
- as part of their flexibility, they should be suitable for internal or external verification;
- they should be scientifically based; and
- they should be practical, useful and useable.

Clearly, in meeting these broad principles ISO14001 can only provide a framework for management, rather than defining or setting targets. ISO 14001 and ISO14004 (ISO 1996b) describe the components and characteristics of an EMS based on a simple 'plan-do-check' approach, with the following key elements (ISO 2002):

- development of an environmental policy and the requirements to meet the policy;
- planning processes that identifies all significant environmental aspects of an organisations operations, including its processes, products and services, as well as the goods and services used by the organization;
- establishment of clearly defined objectives and targets for improving environmental performance;
- a system for implementation and operation that includes clearly defining responsibilities, ensuring staff awareness and competence, providing adequate internal and external communication, a documentation system, and procedures for operational controls and emergency preparedness;
- checking and corrective action including the monitoring, measurement, and recording of the characteristics and activities that can have a significant impact on the environment;
- record keeping in respect of management and audits; and
- a review process for senior management to assess the suitability and effectiveness of the EMS at appropriate intervals.

2.1 Significant Environmental Impacts

An environmental aspect is defined in ISO 14004 as an element of an organisations activity, products or services than can interact with the environment. ISO defines 'environment' as the surroundings in which an organisation operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelation. Surroundings in this context extend from within an organisation to the global system. An environmental impact is any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's activities, products or services. A significant environmental aspect is an environmental aspect that has or can have a significant environmental impact.

Experience with implementation of ISO 14001 in local hotels suggests that identification of longer term objectives and targets for only the most significant environmental impacts is the keys to the success of an EMS. It is important to focus only on the most significant impacts, to ensure that the EMS is not encumbered with unnecessary procedures and documentation

that address minor aspects. Otherwise there is the likelihood of over-complication and significantly increased workload and costs, without achieving significant additional benefits.

2.1.1 Global Aspects. The Hong Kong SAR Government has been pro-active in responding to international initiatives to reduce global warming and ozone depletion. Phase-out of CFCs and halons has long since been on the agenda. Because buildings account for a significant part of Hong Kong's energy consumption (http://www.emsd.gov.hk/emsd/c_download/1999_HKEEUDB_new3.pdf) the Government's Energy Efficiency Office has been promoting energy saving through its voluntary building labelling scheme (Electrical & Mechnaical Services Department 1998), and demand side management through a schemeof subsidies. There has been relatively little activity on other resource aspects, although reducing the use of timber in construction projects has been one target.

2.1.2 Local Aspects. The major local concerns are waste disposal at landfill, pollution of water resources and the harbour, and air pollution. Adverse local microclimates, heat islands and air pollution by vehicles present problems for buildings, in terms of energy use for air-conditioning and potential contributions to indoor air pollution.

It is reasonable, therefore, for those engaged in the management of facilities to focus their attentions on energy and water savings, as financial benefits through reduced utility costs and sewage charges will accrue. This is also true to a much lesser extent for waste management, given the few opportunities for recycling that currently exist. Purchasing practices may also be included in the policy goals, especially where these involve materials hazardous in health.

2.2 Indoor Environments

In non-industrial settings there is a strong link between occupant satisfaction and productivity, and indoor environmental quality, as defined by thermal comfort indices (temperature and relative humidity, lighting quality, the aural conditions, and indoor air quality (IAQ). IAQ can be judged in terms of 'freshness', as indicated by the level of carbon dioxide, and 'cleanliness', i.e., the absence of pollutants at harmful levels. IAQ depends on the pollutant load in a space, and the amounts of outside (ventilation) air brought into the space to dilute the pollutants. The Hong Kong SAR Government's proposed voluntary certification scheme for the management of indoor air quality (Indoor Air Quality Management Group 1999) proposes quit strict benchmarks for air quality. Upon implementation it is likely to provide significant impetus to improve the indoor environments of many offices and public buildings.

In hot and humid climates, the outside air needs to be cooled and dehumidified, resulting in significant energy use for air-conditioning and ventilation systems. Raising indoor temperature and reducing ventilation rate saves energy, but should only be done in spaces that are over-cooled or excessively ventilated; as to do otherwise will increase occupant discomfort and may impact on health. Similar issues apply to lighting provisions in occupied areas. Clearly, concern for the outdoor environment should not override the priority of providing adequate indoor environments, and managers need to take a holistic view of total building environmental performance.

3. OBJECTIVES AND TARGETS

ISO14001 certification does not define or quantify the actual environmental performance of an organisation. With this voluntary approach the objectives and targets set by an organisation may be marginal, and could be well below potential. So-called building environmental

assessment methods (BEAMs) can provide guidance for facility managers when establishing the objectives and targets of an EMS appropriate to buildings.

3.1 BEAMs

A number of BEAMs have been developed that identify the most significant impacts of buildings. Ideally, a BEAM would embrace the life cycle performance of buildings, but those currently available focuses either on new designs or existing buildings of a particular type. Examples of the latter are BREEAM (Baldwin et al 1998) and HK-BEAM 2/99R (Centre of Environmental Technology Limited 1999) for office buildings, and HBEAS (Hong Kong Hotels Association 2000) for hotels.

Generic to BEAMs is the identification of global, local and indoor environmental aspects associated with site development and use, energy consumption, water use, materials and waste, and indoor environmental quality. Compliance with applicable regulations is either assumed or becomes a prerequisite in the assessment. For non-regulated aspects, the benchmark for minimum performance (zero credit) may be set at the prevailing performance norms for the particular building type and setting. Criteria may be performance based, such as energy consumed per square meter per annum, or feature specific, such as energy efficiency features (see Table I). Given that BEAMs can provide holistic approach to assessing building performance, there is inevitable trade-off between 'consumption' and 'service provision', such as between installed lighting power densities and delivered lighting performance.

Table I Examples of environmental performance criteria in HK-BEAM

Feature specific criteria addressing global aspect:

- 1 credit where heat recovery is provided on the general exhaust from the air-conditioned spaces.
- 1 credit for providing heat reclaim on chillers for winter space heating or other hot water requirements, or where there is no provision of winter space heating.

Performance based criteria addressing local aspect:

- 1 credit for demonstrating peak electricity demand less than 160 VA/m^2.
- 2 credits for demonstrating peak electricity demand less than 140 VA/m^2.
- 3 credits for demonstrating peak electricity demand less than 120 VA/m^2.

Performance based criteria addressing indoor aspect:

- 1 credit for demonstrating:
  - a ventilation rate of 8 l/s per person or above is achieved in office premises in which smoking is not permitted, or
  - the ventilation rate meets ASHRAE or CIBSE recommended ventilation rate for a smoking environment, or
  - through proper measurement that the carbon dioxide level in offices premises with an occupant density equal or greater than the design density is less than 800 parts per million.

4. DEVELOPING AN EMS

It is important to define clearly in the environmental policy exactly the intentions with respect to environmental improvements that are to be undertaken. Initial focus on compliance with legislation, energy and water use, and perhaps waste management will be cost effective.

Given that a building and its engineering services have the most significant environmental impacts the development of the EMS is best served when the initial environmental review includes building and engineering system technical audits (indoor, energy, water, etc). If outside help is engaged it is advisable to employ a consultant familiar with the technical

aspects of building operation and maintenance, so that advice would be forthcoming on where to focus attention, and what environmental performance gains and potential cost savings are in prospect. The steps towards ISO14001 certification then includes:

- conducting the gap-analysis and initial environmental review, to identify the significant issues relating to environmental performance. The gap analysis should identify the condition of the building interiors and the exterior, the major building services equipment, and resources supporting operation and maintenance. Walk through surveys and preliminary audits and analysis of basic data should identify internal environmental problems and obvious performance deficiencies;
- the development and implementation stage to provide assistance to staff with evaluation, documentation, development, and operator training for implementation of the EMS; and
- a pre-certification audit to assess the adequacy and effectiveness of the EMS as it relates to the defined significant environmental aspects (impacts), then a certification audit to review the effectiveness of the EMS.

Given the 6-12 month time span for implementing an ISO certified EMS there is ample time to benchmark consumption, assess equipment performance, and determine the main indoor environmental indicators, much if which can by done by in-house staff. There will be a need for specialist measuring equipment during auditing, which depends on the complexity of the systems and equipment installed, and the availability or otherwise of in-built metering and monitoring equipment, but need not be highly sophisticated or expensive.

5. SUMMARY AND CONCLUSIONS

ISO14001 offers the promise of improved environmental performance in all kinds of organisations. As a generic international standard it can only provide a framework for developing and maintaining an EMS. Take up of the standard has been limited, since managers are not convinced of the additional benefits that can accrue, and are often put of by the cost and lack of technical advice (Chan et al 2001).

In the context of Hong Kong's large centrally air-conditioned high-rise developments, significant environmental impacts arise from operation of the building and engineering services. However, efforts to reduce external environmental impacts should not compromise indoor environmental quality or other services. Facility managers do not need an EMS in order to take action to reduce consumption of key resources, such as energy and water, but if the ISO 14001 structured approach is adopted other important environmental aspects will not be overlooked. An EMS focused on the most significant impacts will capture the greatest gains (environmental and cost benefits) for the least effort and cost for development and maintenance.

The development of an ISO certified EMS to best serve large facilities in Hong Kong should combine development of the management system with building and engineering system surveys, including operations and maintenance practices. The process of gap analysis should include building and system audits, enabling some estimates of potential savings, or cost benefit analysis of any investments.

The availability of BEAMs can help facility managers identify the major environmental impacts associated with their facility, and enable them to establish realistic objectives and targets over the longer term.

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Low-Temperature Combined Floor/Radiator Heating Systems

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1. INTRODUCTION

Thermal performance of building envelopes has noticeably improved during last decades and therefore the heating load has fallen distinctly. That enables reduction of heat transfer areas or alternatively a decrease in the temperature of the heating medium. The latter option is especially interesting from the point of view of sustainability, as it makes feasible to apply alternative heat sources such as heat pumps, solar collectors or waste heat from industrial processes. These systems have higher efficiency if they deliver heat at lower temperature level.

2. DESCRIPTION OF A SYSTEM

2.1 Floor heating

One of the systems suitable for low-temperature heating is floor heating. But the temperature of the floor surface is limited due to thermal comfort reasons. Therefore, the heat transfer area must be much larger then in case of traditional convection radiators. Consequently, it may happen that the whole floor area that is available for heating is not enough to supply required heat stream. In that situation, combined floor/radiator heating systems can prove to be a valuable solution.

2.2 Combined floor/radiator heating systems

In these systems the heat is supplied to the room by a traditional radiator and the warm floor surface. This systems may include specially laid underfloor coil pipes. Such coil pipe may be connected in parallel (Fig. 1a) or in series (Fig. 1b) with a radiator. But when the simple pipes laid underfloor are designed only to supply water to a radiator, they usually provide large amount of heat to the room anyway. This paper deals with such case.

The pipe installed under the floor may be also put in a protective goffered pipe or an insulation pipe. Such methods limit the heat losses in some degree, but still large amount of heat may be supplied to the dwelling through the floor surface. This is a good tendency if the system is designed properly, as it uses some advantages of floor heating.

The dangerous phenomena which can arise are:

1. exceeding of permissible floor surface temperature (29–33°C),
2. lower temperature of the supply water coming to the radiator than assumed in design,
3. heat losses/gains to the adjacent dwellings,
4. “short circuit” between the supplying and return pipe with omission of the heated room.

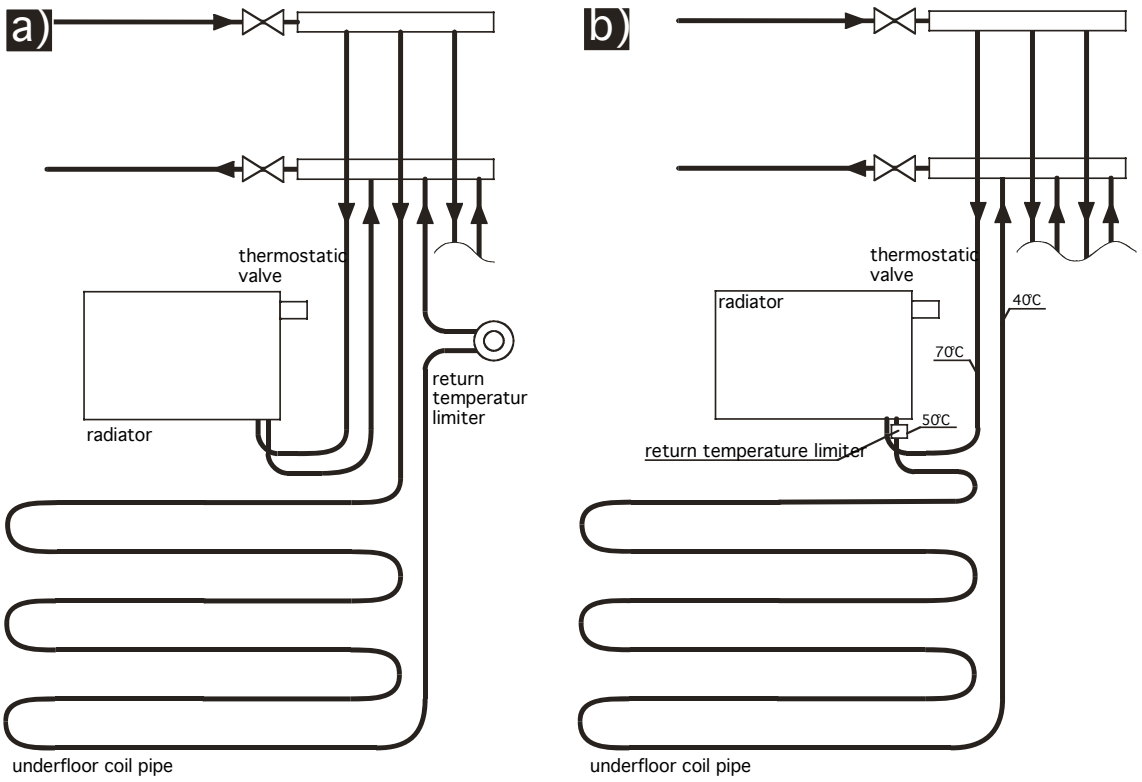

Figure 1 Underfloor coil pipes and radiator:
a) parallel connection; b) connection in series.

As it is shown in Figure 2, large part of heat losses may be transferred to other rooms than that where the radiator, supplied by the these pipes, is installed. If this fact is not taken into account in the design process, it can lead to overheating of some rooms (especially the rooms with large number of pipes, like corridors and staircases) and not proper heating of other rooms.

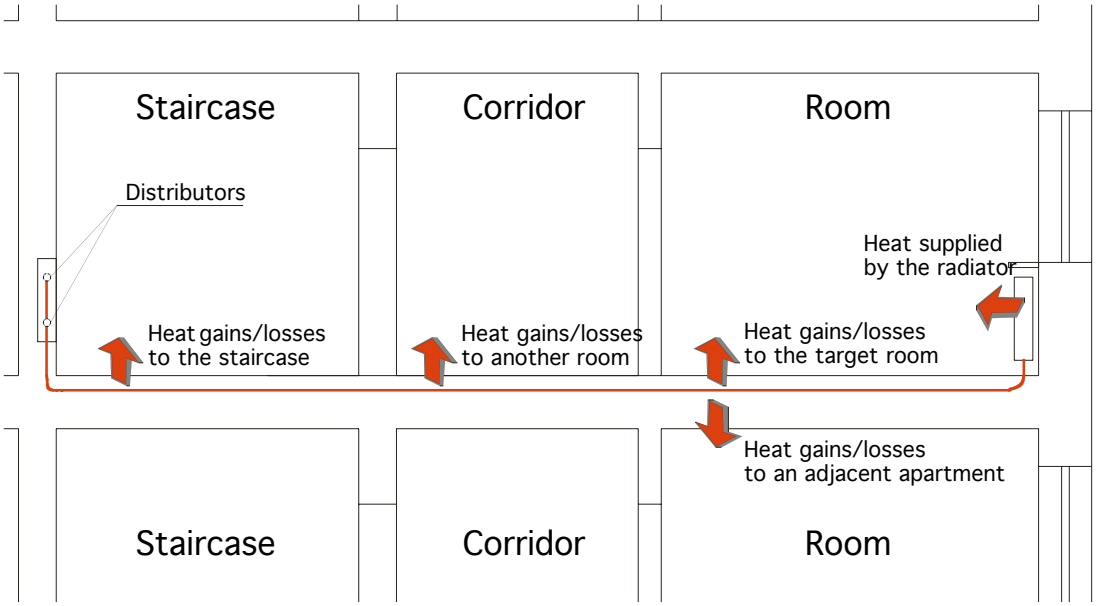

Figure 2 Heat gains/losses in case of water pipes laid underfloor.

The block diagram of such system is shown in Figure 3.

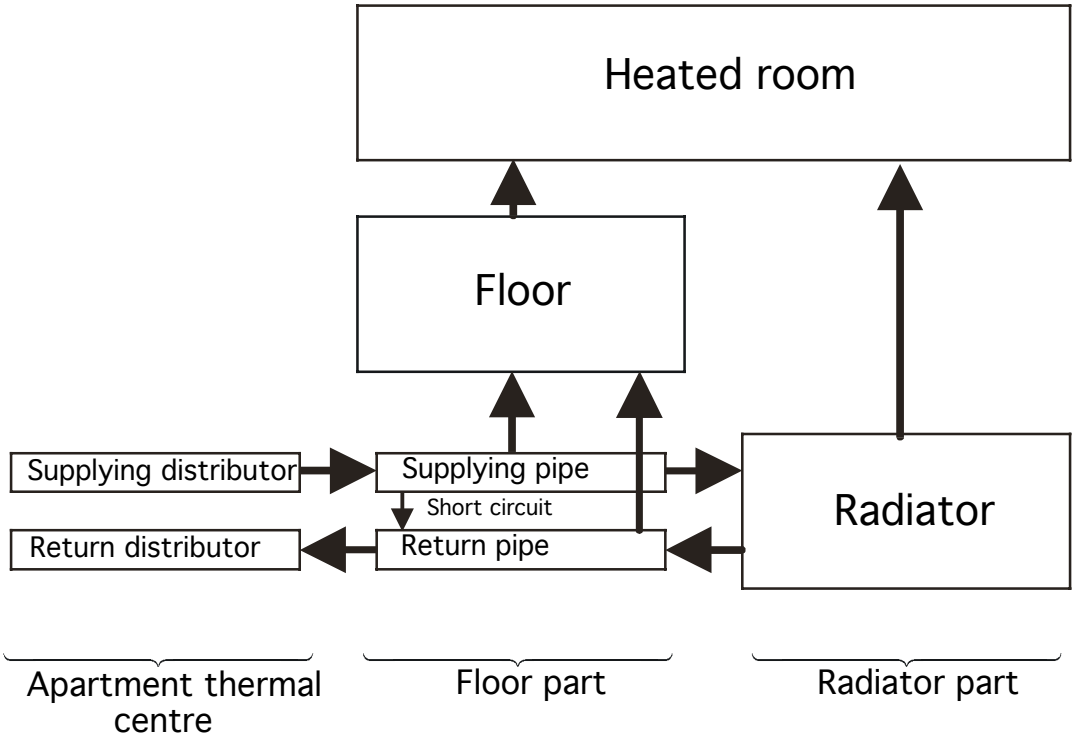

Figure 3 Block diagram of combined floor/radiator heating system in case of a radiator supplied by a pair of pipes laid under the floor. Heat streams are marked as arrows.

3. ANALYSIS OF HEAT EXCHANGE IN THE FLOOR

The presented study analyses the impact of the following factors on heat losses:

1. distance between the pipes,
2. the thickness of the concrete layer over the pipes,
3. insulation around the pipes.

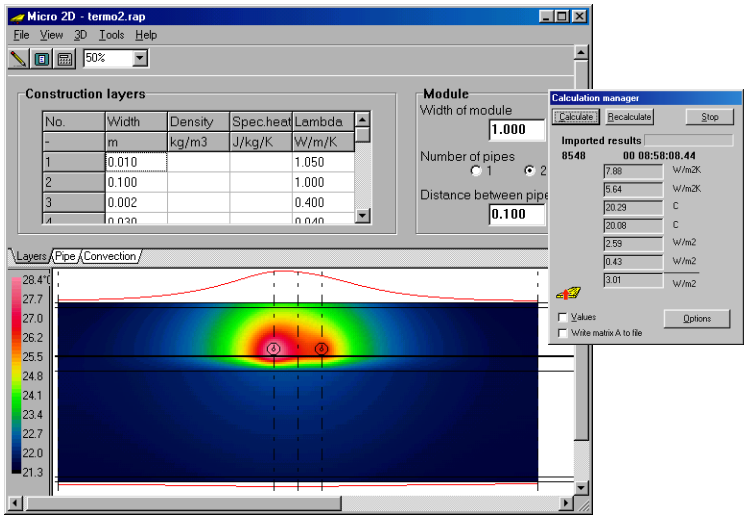

Figure 4 Program *Micro 2D 2.0*.

The study was carried out with use of the two dimensional mathematical model (computer program *Micro 2D*, developed in the Institute of Heating and Ventilation, Warsaw University of Technology).

The floor structure is shown in Figure 5 and Table 1. The pipes (12x1,8mm) are made of polyethylene and have conductivity of 0,46 W/(mK).

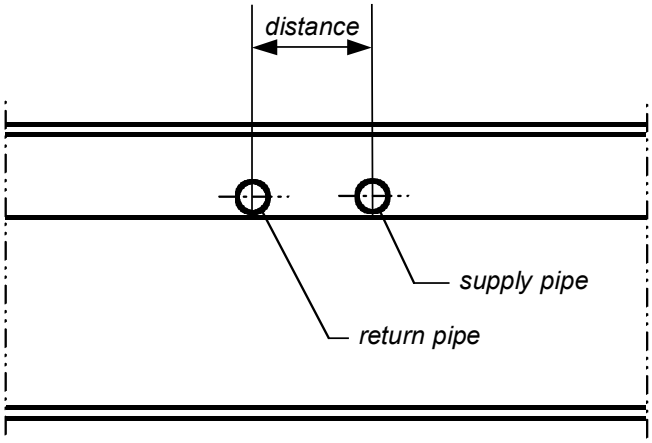

Figure 5 Basic scheme of floor assumed in the analysis.

Table 1 Floor structure.

No.	Layer	Thickness, m	Heat conductivity, W/(mK)	Heat resistance, m^2K/W
1	Tiles	0,010	1,05	0,010
2	Concrete	0,057	1,00	0,057
3	Beam-and-slab floor	0,220	–	0,180
4	Plaster work	0,010	0,820	0,012

Figure 6 shows the influence of the distance between the pipes on heat exchange. The symbols have the following meanings:

q.up. – density of the heat stream to the room over the floor,
q.down. – density of the heat stream to the room under the floor,
q.sum. – total density of the heat stream to the rooms over and under the floor,
q.r.p. – density of the heat stream from return pipe,
q.s.p. – density of the heat stream from supply pipe,
q.s.c. – density of the "short circuit" heat stream.

Higher distance between the pipes means higher heat stream to the rooms over and under the floor, as a wider stripe of the floor works as the floor heater.

The "short circuit" heat stream increases when the distance gets smaller. When the distance between the pipes' axes is 5 cm or higher, there is no "short circuit" heat stream at all.

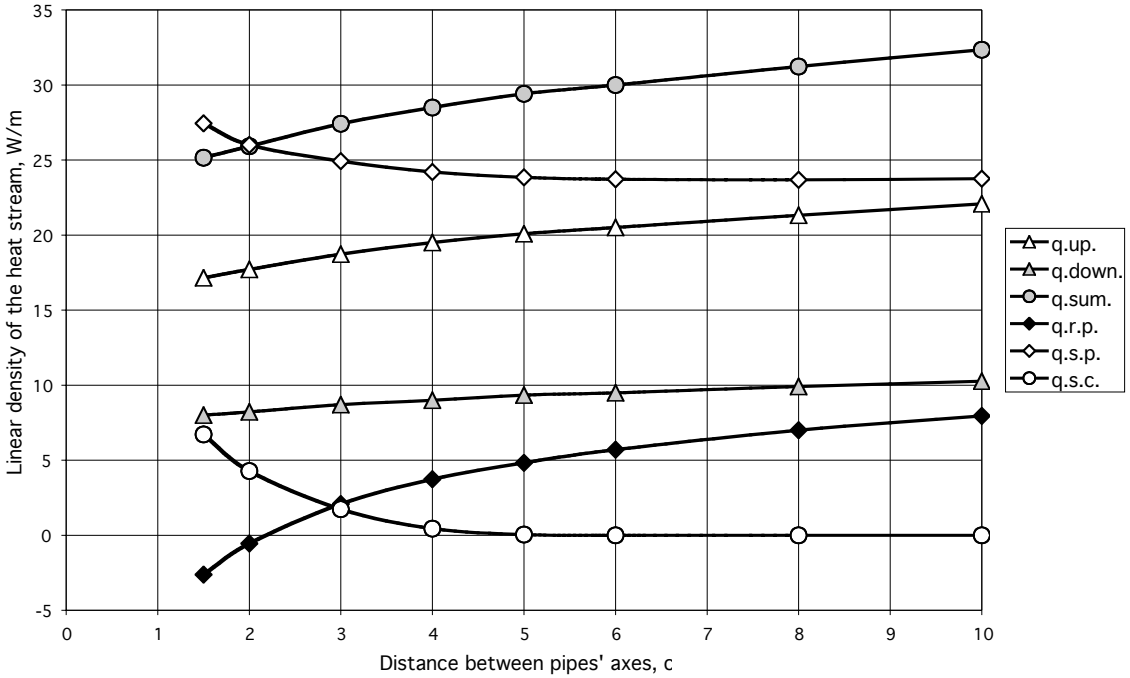

Figure 6 Heat exchange analysis in dependence of the distance between the pipes. Water parameters 40/30°C.

Figure 7 illustrates the influence of the thickness of the concrete layer over the pipes on the heat streams. When the layer over the pipes gets thicker, less heat is transferred to the room over the floor and more – to the room underneath. In the presented case there is no "short circuit" heat stream, because of the distance between the pipes.

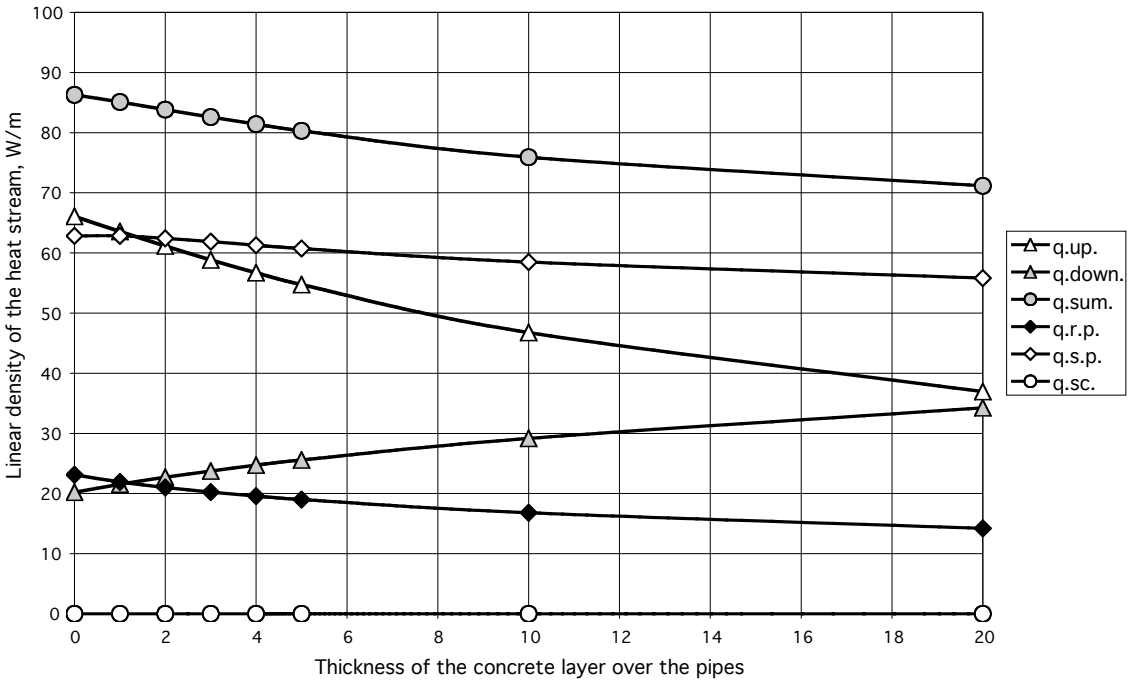

Figure 7 Heat exchange analysis in dependence of the thickness of the concrete layer over the pipes. Distance between pipes' axes equals 5 cm. Water parameters 70/50°C.

Figure 8 demonstrates the influence of the insulation on the heat exchange in the floor. Use of the 9 mm insulation (external diameter equals 30 mm) reduces considerably (by 78%) heat losses from the pipes. The insulation of 13 mm gives 14% more reduction in comparison to 9 mm. With higher insulation thickness a very small "short circuit" is observed. This is due to the fact that on the external surfaces of the insulation pipes the temperature is in that case comparable to the air temperature in the rooms.

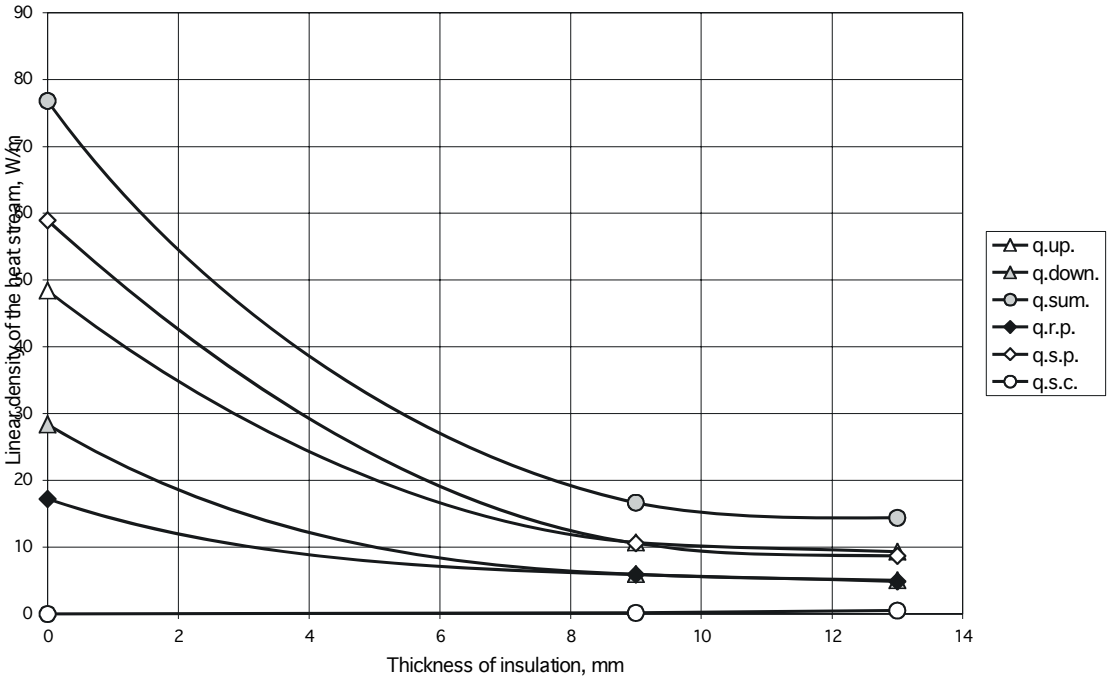

Figure 8 Heat exchange analysis in dependence of the thickness of the insulation pipes. Distance between pipes' axes equals 5 cm. Water parameters 70/50°C.

4. CONCLUSIONS

It was shown that water pipes laid underfloor supply considerable amount of heat to the dwellings. Even when the pipes are insulated, some heat is transferred to the rooms. Therefore that heat exchange should be taken into account in the heat balances of the appropriate rooms during the design process.

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Design, Systems and Process improvements for a High Performance Midrise Apartment Building

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1. INTRODUCTION

The Hickory Consortium has undertaken a case study to document the design, development and construction of a high-performance mid-rise residential building in Cambridge, MA. The 311-unit Cambridge Park Place Apartments project at Alewife utilizes the Integrated Development Approach and LEED certification, as well as system-based design principles developed by Hickory Consortium with the U.S. DOE Building America Program. The project offers a singular opportunity to understand the interrelated process that utilizes systems-based design and the most current tools of "green development". The goal of the Cambridge Park Place Apartments is to result in a high performance building that meets energy efficiency, sustainability & quality expectations while successfully competing in the open multifamily housing market.

In this report we'll discuss the opportunities identified and taken toward sustainable, high performance building, and present some of the issues that have emerged in the team's effort to utilize LEED and the Integrated Development Process. We provide an overview of the project and current progress, pitfalls and results of analysis and testing. We will discuss the process and lessons learned that will inform future work.

2. PROJECT OVERVIEW

The Cambridge Park Place Apartments project will comprise 311 apartment units on a 3.3-acre site. The area has been an intensively used industrial area since the 19th century. The location of a major mass transit station in the area in the 1980s generated dense commercial development. The surrounding area has come to be dominated by commercial land uses such as office buildings. For many years, the City of Cambridge has been encouraging more balanced development to include housing.

Oaktree Green Development is making maximum use of the site for residential building, some retail, and limited on-grade parking, while responding to current flood plain conditions and traffic issues. The project is at an ideal location for commuters going to central Cambridge and Boston, with direct link to downtown Boston, Cambridge, and major universities less than one block away. Many area shops and amenities in the area are within walking distance. Bicycle paths from western suburbs also convene at the Alewife transit station. The 36 units of affordable housing in the project will be a significant contribution to the publicly managed housing stock in the City.

The overall project goals for Cambridge Park Place Apartments at Alewife are:

- Build high-quality, multi-family rental housing convenient to residents working in Boston and Cambridge
- Maximize the environmental benefits and cost performance of a building located in a dense urban area adjacent to mass transit
- Reduce overall energy demand and consumption by 30% to 40%
- Create healthy indoor air quality for tenants and staff
- Reduce construction waste and associated costs
- Reduce water use and related costs
- Reduce maintenance and operating costs over the life of the building for owner and tenants
- Achieve LEED certification at standard construction cost
- Achieve marketing benefits of well-designed, competitively priced, resource-efficient, multi-family building

3. PROJECT STATUS

The project is currently in the construction phase with nearly half of the units completed (scheduled for occupancy in June 2002). A comprehensive commissioning and testing program has been carried out simultaneously with the construction process, and has added to the quality of construction in many ways.

4. SIGNIFICANCE OF THE PROJECT

The Cambridge Park Place Apartments project at Alewife offers an opportunity to expand the impact of the US D.O.E.Building America Program to a new residential building type. This housing sector receives little attention from energy agencies before construction, yet a single multi-family building can bring hundreds of energy-efficient homes into the housing market. The Cambridge Park Place Apartments project also provides a unique opportunity to document the interrelationship between systems-based construction methods developed by the Hickory Consortium in the Building America Program and related programs such as the LEED certification program for commercial buildings, and the LEED residential certification currently under development by the U.S. Green Building Council. Most directly, the Cambridge Park Place Apartments project at Alewife provides an opportunity to:

- Develop a systems-based approach to a new residential building type
- Demonstrate the viability and advantages of a high performance building for the competitively priced, mid-rise residential housing market
- Create a replicable, sustainable design and development process

5. OPPORTUNITIES AND STEPS TOWARD INNOVATION

5.1. Applying the LEED criteria for High Performance Building

The developer and the project team are using the LEED rating system to achieve a LEED-certified "green" building. LEED (Leadership in Energy and Environmental Design) is the leading green building certification system for commercial buildings in the U.S. It is based on design, construction, and site treatment criteria developed by the U.S. Green Building Council. Cambridge Park Place Apartments is the first application of the LEED rating and certification system for a multifamily residential building.

Energy modeling was initiated before the architectural drawings were complete in November 1999. The first step was to evaluate the impact of changes in envelope and infiltration on the

energy demands of the apartments. The team reviewed and debated the cost-benefits of available systems, materials, and design choices as they evolved and agreed on specific criteria. A key challenge of this project is consensus on first-cost versus long-term investments in quality improvements for the project. Untried environmental technologies and choices are perceived as a risk and added complexity by the developer. Long-term payback may not be an option for a developer who hopes to see positive cashflow on the project within the first year of completion, and who may be putting the project up for sale in the secondary market soon after completion. Even when first-time costs are the same, the level of risk associated with innovative technologies and systems is considered costly in a complex project such as a 311-unit multi-family building.

In view of the above constraints, it has been vital to demonstrate that the measures being proposed can reduce both long term and initial costs. Early efforts concentrated on convincing the mechanical contractor that envelope changes could be legitimately translated into lower loads and smaller system sizes. Improvements in walls, windows, infiltration, ducts, and internal gains lead to the reduction from 1.38 to .73 tons of cooling capacity per apartment. The net result of this early analysis was the reduction in cooling system size from 500 to 300 tons, saving approximately $300,000 in initial cost. This choice also offers the opportunity to avoid using environmentally destructive CFC or HCFC refrigerants, and can be highly efficient. A high efficiency (88%) boiler is specified for heat and hot water.

5.2. Site Selection and Treatment

The Cambridge Park Place Apartments site is located within the dense urban grid of Cambridge, MA, and is directly across from the Alewife T stop. Therefore, the project team had chosen intense development and massing of building of the site to maximize efficiencies for energy and cost, and to make use of regional transportation networks. Pedestrian walkways create easy access to nearby public transportation, offices, and shops. Covered underground parking includes bicycle racks, as well as cars. - There is also space for car pooling, Zip car car-sharing, and stalls adaptable to electrical car charging.

Oaktree Green Development has worked closely with the City of Cambridge Conservation Commission to mitigate and improve conditions on the formerly industrial site. A storm-water management plan, including storm water collection on the roof (Pervious pavement materials and slowed release of rainwater run-off from roof surfaces) will mitigate water issues on the site, which lies on a 100-year flood plain, by 40%. The covered underground parking area and much of the site will be restored with native plantings. Ground water and storm retention water will provide much of the irrigation for plants.

5.3. Building Performance and Costs

Opportunities for building performance improvement at Alewife were explored and evaluated by the project team during the schematic design phase of the project based on criteria developed by Hickory Consortium through the Building America Program and for LEED certification.

5.3.1. Building design for optimized solar, wind, and view orientations relative to zoning and site configuration.

The building is sited and designed to maximize the use of solar energy in the winter. The U-shaped courtyard faces south and the units on the courtyard will receive solar energy as suntempering – a significant effect for a building of this scale. The courtyard is expected to provide a warmer than normal microclimate, further reducing building heat use.

5.3.2. Reduced energy demand and associated costs through appropriate building massing, thermal envelope treatment, reduction of internal loads, and optimization of mechanical systems design and coordination

Building Envelope: Based on systems engineering studies and recommendations by the HC team, wall insulation was increased from an effective R-8 to R-15 at Cambridge Park Place. The envelope treatment is expected to significantly reduce heating, cooling, and DHW loads.

Windows – Based on a thorough study of available products, the HC team recommended and the architect specified low-e, argon-filled, fiberglass windows with low solar heat gain coefficient. We were fortunate to be able to purchase fiberglass windows with a U-value of .29 and a solar heat gain coefficient of .33. This dramatically reduces cooling and heating loads, since windows are the largest contributors to those loads.

Internal loads - Internal loads to be reduced by Energy Star appliances and lighting as well as maximized daylighting. Lighting power loads have been dramatically reduced through lighting design. All permanently installed lighting in building are fluorescent. The total wattage for the common spaces and apartments is 226650 W resulting in an installed Lighting Power Density of only .75 W/SF. It is worth noting that the ASHRAE prototype discussed above allows 1.2 W/SF and that the Massachusetts State Energy Code assumes 1.75 W/SF. The impact on the cooling load is significant.

Air infiltration and leakage -The Hickory team recommended and the project architect specified performance standards for air tightness of not more than 2 square inch per 100 square feet of shell area at a pressure difference of 4 Pa. A key issue for air infiltration in a mid-rise building is leakage from and to the shafts rising through the building.

Blower door tests confirming air tightness and ventilation have be performed on several units and will be done on 20% of the units on a random selection basis. Blower door tests were performed on the first completed units, which serve as a prototype for trades in learning the required skills, and proving the concept that air sealing can meet the required levels. These tests showed that the envelope was very tight, but ducts and through floor chases needed more sealing.

HVAC Systems - The HC team recommended and the project engineer specified a 2-pipe change-over central system with electric back up fan coils. The change from a split hot water/heating system to the 2-pipe change-over central system is projected to save 26% annually on energy costs. Key advantages of the 2-pipe system were lower initial cost, lower annual cost, reduced energy use and reduced maintenance, availability of high efficiency central equipment, opportunity to reduce pump and pipe size, availability of ozone-friendly refrigerant, and elimination of gas piping to apartments. Variable speed pumps were specified to accompany the fan coil system.

Although the initial reaction of the builder and developers was that the cost of Energy Star appliances was too high to be justified by the rebates available, efforts by the Hickory Consortium helped identify a supplier of competitively priced Energy Star Appliances. Energy Star labeled electric ranges, refrigerators, dishwashers, lighting, and programmable thermostats were purchased for the project, and some very low cost refrigerators exceeded energy star requirements.

5.3.3 Predicted Energy Savings:

Cambridge Park Place has been designed to improve energy performance relative to standard buildings of the same type, and to achieve good performance in other areas of sustainability consistent with LEED ratings. When completed, the building will have 312 units (including a permanent model unit), as well as a great deal of common space. As part of the partnering process with the builder, early completion of several units made it possible for early testing to allow bugs to be worked out of the system and allow some new approaches to be tried in a low risk environment. This testing has also been useful to learn how to do airsealing, ventilation installation, and other conservation related tasks in more efficient ways. The base case estimate of annual energy use for the building was 3,138,000 kWH and 78,888 Therms of natural gas. The estimated cost for energy was $447,381 per year, with electricity making up 85% of the total.

Studies of the building were carried out using Visual DOE2 a graphical user interface version of DOE2e, an hourly thermal simulation program. The base case was constructed using values typical for buildings of this type, which are built to meet the ASHRAE 90.1 1999 Energy Code, using minimum equipment standards. The latest DOE2 modeling shows that the advanced design and integration of building systems is expected to result in a reduction of nearly 33% in building energy use and a 48% reduction in annual cost. Because the only use of fossil fuel is for heat and hot water, electricity is the largest part of the energy consumption. Indeed, due to reductions in internal gains due to high efficiency light and appliances, the heating load is nearly as high in the well insulated building as in the base case building (it would be much higher without the better envelope for loss reduction.

The results of simulations indicate major savings in both electric use and natural gas use for heat and hot water. Due to reductions in cooling load, equipment inefficiency, and lighting & appliance power density, the electric use estimated for the building was reduced from 3,138,000 kWH to 1,441,208 kWH, or 45%. Likewise, the gas use was reduced from 78,888 Therms to 75674 Therms (5%). The overall energy savings is roughly 33% and the overall annual cost reduction is estimated at $209,444 per year in energy cost. The energy savings based on energy costs would be 48%, and the life cycle cost savings were 4.9 million dollars over the assumed 50-year life of the building.

5.3.4. Improved indoor air quality for tenants and staff through materials choices and ventilation treatment

Ventilation - preliminary construction specifications specify that the apartments meet or exceeding ASHRAE 62-89, and provide a minimum of 15 CFM per occupant when occupied. Bath fans provide continuous ventilation and drying for the baths and the units themselves. These fans are connected to risers that terminate in convection spinner caps at the roof. In order to reduce the likelihood of excessive airflow under strong driving force conditions, each stack are equipped with an American Aldes Constant Airflow Regulator, which limits the flow to a maximum of 350 CFM per stack.

Materials - The HC team recommended and the project architect specified low VOC paints, carpets, and adhesive, wood products and cabinets for Cambridge Park Place Apartments.

5.3.5. Reduced water use and related costs

Energy Star labeled appliances were included in all units. Comparative evaluations of Energy Star labeled dishwashers, clothes washers, and low-flush toilets showed significant water savings over code. Storm water retention and reuse on the site will reduce the impact on the city's storm water drainage system and reduced irrigation use.

5.3.6. Partnering, Performance Testing, and Commissioning

This project has been approached from a cooperative point of view, with the architect, developers, and general contractor participating in the design process and choices of systems and materials. Materials and specifications were priced by subcontractors for bid purposes and to get an initial reading on the potential cost implications of the design features in a highly competitive market. The broadest possible participation was promoted for the project partnering meeting. We have found that establishing lines of communication, promoting understanding of the reasons and goals for the things we are including, and making the subcontractors feel a part of something more than another building all help to produce a smoothly flowing, cooperative project.

Though the specifications require air tightness as well as quality construction, continuation of the partnering process is essential for a successful project. Part of that process is the hiring and participation of the owner's project manager and of a commissioning agent. The commissioning agent, Jim Fickiet of EHE inc. is carrying out the commissioning of equipment and installation on the project. Commissioning is an integral part of the LEED certification process and systems-based approach developed by Hickory for DOE. Basic commissioning will involve ensuring that systems, including control systems, are operating to design specifications and that various systems are working well in relation to each other. We are using the ASHRAE commissioning guideline (ASHRAE Guideline 1-1996) as part of the process, but there are several areas that go beyond that guideline.

6. CONCLUSIONS:

The process used for this building will result in a building that meets the criteria for LEED certification, while containing costs to those of similar buildings in the same market. Current estimates show a LEED score of at least 28 points, with 26 required for certification. It is clear that, like other building projects, the process cannot end with design. Several examples of specification switching and performance shortfalls were discovered during the commissioning tests and are being corrected. These would not have been detected in a normal process. The partnering process helps to avoid adversarial situations in these cases, and helps provide a smooth path for construction to proceed. As we gain experience with sustainable building, we learn what's important and what works. The lessons learned about systems, materials, specifications and process are now all part of the foundation of the integrated design process. Though other lessons await, incorporating these in future projects will be quite a bit easier. The builder's experience will also become part of standard practice, and the wealth of overall learning will continue to grow.

Sustainable Public Spaces - Urban Design and Transformations vs. Myth, Ritual and Ideology

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1. INTRODUCTION

The city, as a result of social processes, represents the actual condition of the society. At the same time, this amalgam of people, space and buildings should be a secret well from which the primeval human need for ritual behavior derives its strength, meaning and validity. Unfortunately, the contemporary city is loosing its traditional values and the eternal duality between 'secret' and 'profane' becomes, in our modern world, just an intellectual phrase without the necessary metaphysic foundation.

Caught in the web of new technologies, strong economic forces and intrinsic elements of everyday life, urban space can no longer respond to the rational and irrational demands of its consumers. It is almost impossible to recognize and decode inherited archetypes, to enjoy discovering their mystical meanings and to find the well-hidden power of inherited memories and self-sustaining life. Consequently, the lack of urban identity brings new problems to the city and its physical structure unable to respond at twists of fortune created by nature and people. Therefore, the historical connection between urban space, its activities and ritual values for the community could help us to (re)shape our built environment and improve its human dimension, which is important for its existence.

2. THE ROLE OF MYTH, RITUAL AND IDEOLOGY IN THE CITY LIFE

Urbs - the city - is usually defined as a significant concentration of people, wealth, power, buildings and open spaces. At the same time, the city should be a historical and multiscalar product. Depending on time, space and human factor *urbs* has a twofold role in our lives. It can be used as a stage for our everyday or extraordinary rites and/or it can be a major participant in them.

The city as a social artifact radiates unique energy and commitment. It has a strong impulse for surviving and a need for eternity hidden deep inside its urban being. Due to the fact that all architecture proposes an effect on the human mind it is not surprising that the ritual, through centuries, was an inseparable element of its creation. Every cityscape and every building shaped by a ritual do not just have an everyday purpose - they are expressions of one time and one society.

Evidently, the mythical role of the ritual is very important for the community. Through its basic characteristics - violation of the established prohibitions and liberation from negative and socially unacceptable impulses, ritual supported by acceptable mythological background represents a unique force. A person involved in ritual ceremonies is able to perceive its being from a different perspective and a group becomes aware of its strength and coherence. Consequently, the ritual participant transforms the temporary and profane state of mind into a secret and universal condition.

Rituals and celebrations, as repetitive and periodical events, remind us of life cycles and the eternity of the Universe. Unfortunately, the personal feeling of immortality could be used as a device for ideological manipulation, especially in autocratic systems. However, every system follows a basic ritual pattern that includes sacrifice, catharsis, exaggeration, act of giving and. constant presence of authority. At the same time, the most important ritual principles are formalisation, traditionalism, archaic and game elements and, often, spectacular features. All of them are usually incorporated in the urban space that should provide scenery for ceremonial events of the community.

The background of surrounding ideology, its myths and rituals always accompanied the act of creating places for different human purposes. Therefore, through a proper understanding of the act of planning, designing and making urban places and settlements, we could easily understand ourselves. Sometimes these urban rites had a very important mundane and cosmic role, but sometimes they were just a routinized event. The perfect shape of the city matrix usually ought to reflect a divine ruler and presupposes of an ideal society. Founding rituals and myths of propitiousness follow its inauguration, but after this moment of divine generosity, the city becomes an inseparable part of human history. Finally, it offers its physical structure as a place for every aspect of life - from symbols of the power and eternity to everyday needs, from divine glory to human dust.

2. SHAPING THE URBAN PUBLIC SPACES

According to one of the possible classifications, this time given by Fernand Braudel, we could define three major city types - open (ancient Greece and Rome), closed (medieval) and towns from the Renaissance onward, controlled by the state or a powerful ruler. Their urban structure was shaped by different historical conditions and the role of rituals was subordinated to the highest power of the society.

At first, cities represented a divine prototype made by rulers in order to create their own microcosm. Therefore, this manifestation of the supreme ruler's will was used every time the highest authority, as a representative of the official ideology, had to be approved and imposed on the society. It was a kind of initiation ritual for the new system and it has been used up to our time, especially for new towns and capitals (for example in conquered or colonized countries or when they became independent). From Khorsabad, Constantinople, Rome, St. Petersburg to Versailles and Paris, from totalitarian experiments - Berlin, Rome and Moscow to democratic capitals Washington, Chandigarh and Brasilia, the same principles were applied, although under the different circumstances. The main aim was to emphasize a new ideology and its validity, but the stands opposed each other completely.

This celestial model, used by ancient regimes, was transformed later to the *polis*, a concept preferred by ancient Greeks and later reused during the Middle Ages. This populist city created by the will of ordinary people (citizens) does not have monumental ceremonial complexes shaped for an absolute ruler. Instead, it has democratic places suitable for everyday

rituals and ceremonies, profane activities, and the decision-making process shared by every member of the urban community. The rituals are different too. The glamorous epiphany, triumph and imperial adventus, as represented by the inherited absolutist ritual system, together with more civil ceremonies become a very interesting symbiosis of archaic inheritance, pagan rites and new Christian chronology. Different ceremonies, games, triumphs, coronations, funerals, carnivals, season holidays, mysteries and feasts are true metaphors for the social reality - the mixture of cultures, traditions and dynamism of the medieval society.

Depending on the supreme ideology, public spaces and public buildings derive their logic from rituals too. Created under the radial, concentric, orthogonal or completely organic patterns, those spaces connect and, hopefully, dignify different town districts that usually have administrative (ruling), religious, commercial and residential role.

2.1. The Square

Perceived like a civic center and/or market place the square has an important role in the urban ritual. Usually combined with a ceremonial axis, it should be a place where citizens can freely speak and express their independence and self-awareness. Unfortunately, as one of the main ritual points in the city, the square is usually an object of manipulation. Considering its danger to the ruler, the size and functions of squares are changeable. It can be too small or too large but the result will be the same - it will be difficult to gather a critical mass of people able to dethrone the ruler.

The city square has many functions. However, as a place of everyday rituals - shopping, traffic and communication, or as a stage for special celebrations, games and even extreme events, like a revolution, this piece of city tissue offers exciting surrounding for human physical and psychological needs. The only, but eternal question for the architect profession, is how to determine the right scale of its space, proper combination of functions and, finally, how to give a breath of life to this social creation, whose importance for urban survival is incontestable.

2.2. The Street

As a line that connects urban sites that are important to one society, the street, beside its practical function, presents strong political statement. There is no celebration without the street. Its urban frame, materialization, proportion, regulation, and even function, expresses the accepted way of life or the strong ruler's intention to impose and mould desirable social attitude.

The ceremonial streetscape is especially important along the ceremonial axis - the most important direction in every city. It usually stretches from the main urban gates to the most important public buildings representing the community structure and sources of power (religious, political or economical). Buildings along such a route could be a palace, a temple or cathedral, a town hall, a parliament, a court of law, and important cultural institutions like a library, a university, a theater - depending on the period or ideological demands. But, the most important factor for every public space is to be recognizable and readable, adjusted to human scale. Otherwise it could become just a fancy drawing on a flat surface.

3. THE CENTRAL EUROPEAN EXPERIENCE

The towns in the north part of Serbia situated on Pannonia plains, are part of a long thread of continuity – since the ancient times up to present day, during many centuries of their

existence. This fact confirms the thesis that throughout history, towns are always built in the same places. They grow up for quite pragmatic reasons. The locations are often along the rivers or at the crossing of the "main market roads". Their purpose was often to be a market for the exchange of goods or to be a fortress - the boundary between the Ottoman Empire and Medieval European countries.

The main streets and squares are part of the longest thread of the continuity, as they appeared before the towns were completely established. The streets in these old towns usually followed the most natural routes. The squares were established at the crossings of the main directions or inside the fortress in front of the church and surrounded by principal buildings. The width of the streets became related to the quantity of use and importance. Consequently, the dimensions of the squares and concentration of the principal buildings were related to their importance in the urban pattern and urban rituals.

The main streets in our old towns always present direct communication between the main square, the market street and the principal buildings. The proportion and scale of town blocks shape the length of a street and a square. Our experience of a street is dictated by the length of the blocks, the width of the pavement and materialization of its surface. Also, the relationship between the horizontal and vertical dimensions of a street and squares are crucial to our perception of the urban environment (Cathorpe,1993). The proportions of our squares are represented by a ratio between 1:2 and 1:3. The relationship between the horizontal and vertical line (pavement and buildings) is between 1:3 and 1:10 for squares and between 1:1,5 and 1:5 for streets. Along the main street there are only a few blocks, usually between one block and three.

An appropriate sense of scale, distance, proportion, massing, landscaping and even architectural detailing are interwoven into our culture and it was written into the town pattern. In the most of our towns (which were reconstructed in the 19th century), the streetscape is composed of a continuous line. The visual rhythms established by buildings line fa|ades, the style, scale and condition of the buildings, the materials of construction, and the placement of windows and doors are important attributes in defining a street elevation (Jacobs,1985). The visual rhythms established by building line in our main streets are in numbers: 10, 14, 16, 20, 26, 28 and 32. The materials of construction are the same, and the rhythm of the placement of the windows and doors is uniform. The secondary divide of the buildings' fa|ades is in the numbers 2 or 3, dependent on the position of the buildings in a street. The width of the pavement and the number of the stories in the building condition the visibility of an entire fa|ade of a building from either side of the street and square. In the most of the cases the façade of a building is visible and harmonized with the width of a street and square, and the buildings are visible from different angles of view.

A lot of our main streets have trees lining them. These trees, planted along the pavement (the first ones appeared in the 19th century), dramatically affect our perception of the environment giving a different picture of the urban environment through the year. The time of year affects the patterns of sun and shade during the year. It is connected to the species of trees, but also to the height of the buildings and the proportions between the width of the pavement and the number of the floors in the buildings. The quality of light and changes in atmospheric conditions also affect transformation of appearance along the streets and squares and make them more dramatic. The character of the street scene is also defined by street furnishings, including streetlights, benches and kiosks. These elements are changeable through the seasons and they are often related to fashion and trend in urban design.

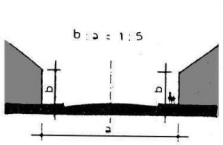
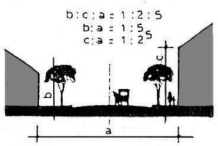
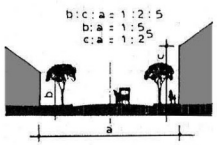
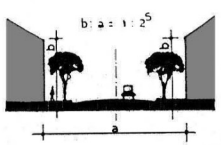
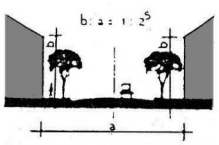
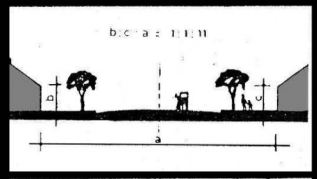
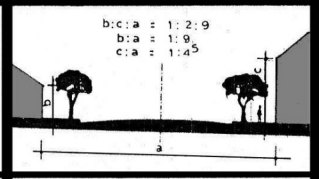
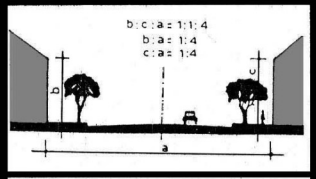
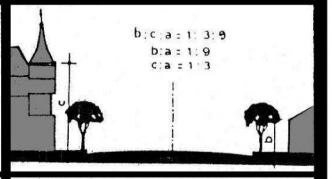
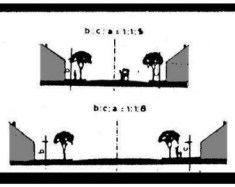
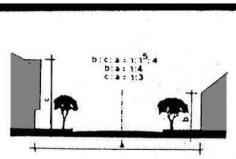
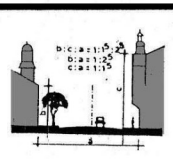
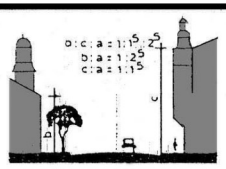
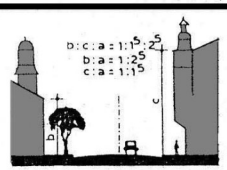
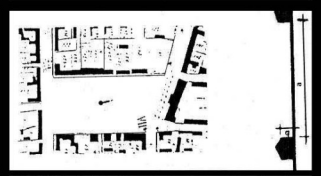
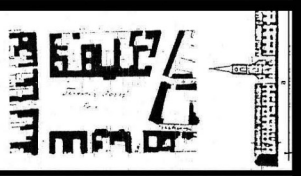
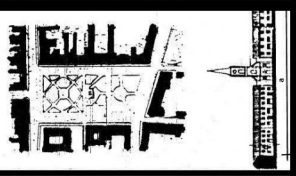
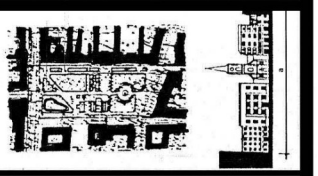
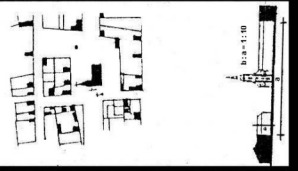
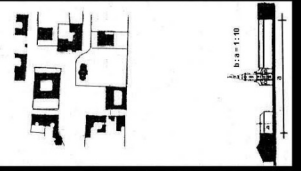
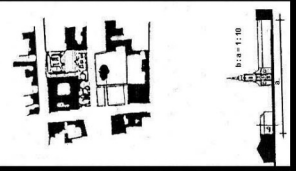
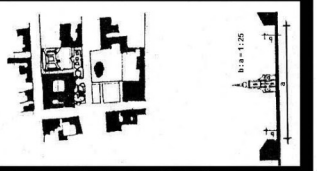
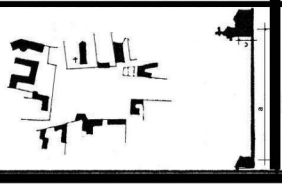
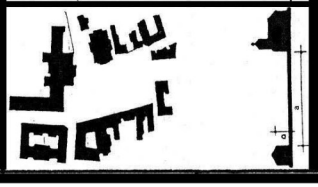
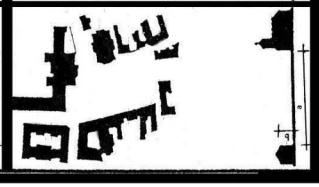
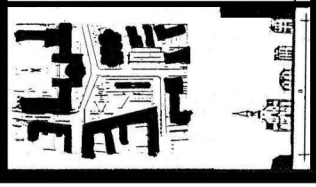
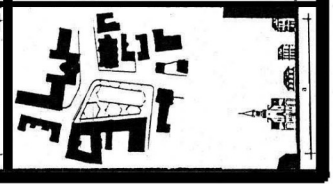
periods / towns / elements		18th century	First half of 19th century	Second half of 19th century	First half of 20th century	Second half of 20th century
STREETS	Pancevo					
	Kikinda					
	Zrenjanin					
SQUARES	Pancevo					
	Kikinda					
	Zrenjanin					

Figure 1 The morphology of the basic urban elements - the street and the square (examples from the north part of Yugoslavia)

During the 20th century we had the problem of the erosion of the cultural symbols in the towns as well as their correspondence to urban activities. Roads without 'urban spirit' are replacing streets and the social role of urban spaces is being replaced by a commercial one. The main street and the square were nothing but a memory. They have lost their important role in urban life. A lot of public spaces were 'demolished' by inappropriate buildings. The image of the town was seriously damaged.

Throughout the centuries, the image of the towns has been created by the visual repetition of elements as well as by unique elements. The churches and principal buildings are usually powerful images of towns that were dominating with their position and height, but the repetitiveness of the towns' pattern, like the buildings from the 19th century in the main street, also represent it as much as does the unique elements. Repetitive elements are the true urban form that expresses the way of life and culture of the community (Lozano, 1990).

We could easily discover similarities between towns in the central part of Europe, because they were established at the same time under similar conditions. If we compare our towns with those in Hungary, Germany, Slovakia, the Czech Republic and Italy, we can notice main similar elements in morphology and urban pattern. In our traditional towns, urban spaces were attractive and inviting and they followed the principle “buildings define the space”. This makes a significant contrast to a philosophy that considers towns as a collection of buildings (which was the philosophy of the middle part of the 20th century). Therefore, a very important task in the future will be to rescue towns (especially their historic central parts, like main streets and squares) from 'demolition', greed and temporary fashion. The reconstruction of these parts has to consist of the elements we can learn from the past. It can help the urban designers to bring the attraction, harmony and “the sense of belonging to the space” to citizens and consumers of the open public places. Obviously, we have to learn again how to build for a timeframe of centuries.

4. CONCLUSION

The sustainable circle of historical urban context could offer very interesting lessons for contemporary planners and architects. At the same time, the continuity of the cityscape and respect for inherited codes of our existence should be the starting point for our new urban investigation. However, the well-known fact that the city should be used as a medium of human expression has to be observed from different angles. It is not enough for urban space to be just a manifestation of someone's power or an answer to everyday needs - it should be a transmitter of progressive ideas and a decoder of symbolic messages that could awake our forgotten subconsciousness.

The only question is are we ready for this intellectual adventure?

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Choice of Building Materials and Products by Environmental Consultants

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1. INTRODUCTION

During the last decade, environmental concern in the building sector has gradually increased. Several international and national agreements and guidelines have led to increased consciousness about the environment. As a result of the Rio declaration in 1992, the Swedish government announced in spring 1994, that it would formulate rules for producers' responsibility in the building sector. To avoid legislation and create a broad co-operation in the Swedish Building Sector, the Ecocycle Council for the Building Sector (BYKR) was formed in the autumn of 1994. The Council consists of the actors in the sector, working together to achieve sustainable construction. A plan of action was formulated in 1995 (BYKR, 1995). One of the commitments was to draw up and provide society with building product declarations by 1997. A template with instructions was drawn up, following in principle the ISO-standard 14021 for self-declared environmental claims (Type II environmental labelling) (ISO, 1999). In this paper, declarations of this type are referred to as building product declarations.

Only a few studies have been found since 1999 dealing with environmental choices of building products in construction projects, but there are several lists describing available systems and tools (Miljöförvaltningen, 1999; SETAC-Europe, 2001). However, there is one ongoing project within the Swedish MISTRA Sustainable Building project, where the environmental aspects of the demonstration project of the Swedish Housing Exhibition Bo01 are evaluated. In a licentiate thesis the possibility of integrating environmental and economic dimensions is discussed (Gluch, 2000). A pilot study, "Assessment of environmental information in the building sector", presented the working methods and tools used by different actors in the building sector to assess environmental impacts of building components (Lundblad, 1999). Some of the findings concerned environmental consultants, who used the same type of guidelines, building product declarations and safety data sheets as today. They were critical of the quality of the building product declarations and found it hard to assess the given data. Lundblad also found that Type III environmental declarations (ISO, 2000a) were rare and considered by small manufacturers to be too expensive to draw up and they were not frequently requested.

This paper is based on an extensive evaluation of the present role of environmental consultants in the building process in Sweden, focusing on their choice of building components and chemical products and the basis for their decisions. Characteristics of the possible decision bases are discussed and improvements to avoid suboptimisations are recommended.

2. METHOD

For this study interviews and a literature study were performed. Five environmental consultants (see References), employed at four different firms, were interviewed. The starting point was the different phases in a construction project: planning, design, construction, and use and maintenance. The bases for their choices of building components and chemical products, and advantages and disadvantages of these bases were discussed. The main questions explored were:

- In which phases do environmental consultants participate and to what extent?
- What do environmental consultants know about building context, economy, technical aspects and users, in the different phases?
- What constitutes the bases of decisions in different phases?
- What advantages and disadvantages are associated with the bases of decisions?
- Are different environmental aspects given priority, depending on the type of studied component?
- Is there a general wish among different actors to include cost and technical functionality in the environmental assessment?

The literature study consisted of articles and reports mainly published in Sweden

3. THE CURRENT ROLE OF ENVIRONMENTAL CONSULTANTS

3.1 Environmental Consultants Participation in Different Phases

Some of the environmental consultants impact the choices of building components mostly in planning and design by their recommendations of building elements. Their recommendations are made on several bases, for example LCA studies, technical reports and guidelines. These consultants do not usually recommend specific components or chemical products and do seldom participate in the construction phase. Other environmental consultants are more specialized in helping clients to draw up environmental programmes and plans, which is normally done in the design phase. As the project has already passed the planning phase choices of building elements and the type of building components are to some extent already fixed. In the construction phase these consultants work with specific choices of components and chemical products according to the environmental plan. Environmental consultants seldom participate in the usage phase with maintenance and refurbishment, but property owners use their guidelines and chemical stop lists.

3.2 Decision Bases in Different Phases

There are several bases for decisions when building components are chosen. Some are provided by manufacturers, others by the consultants themselves or by clients. In different phases of the project, different decision bases are used more frequently than others. Table 1 shows the main bases for decisions and their characteristics. Omitted bases are technical reports, laws and regulations, previous experience, experts' opinions, and environmental programmes and plans. An environmental programme and the environmental plan drawn up for a client are based on laws and regulations; guidelines and chemical stop lists; previous experience; and the client's environmental policy and goals, and ambitions for the particular project.

The user of the presented bases of decisions must have good knowledge of chemistry and ecological sustainability, as well as product knowledge, to be able to assess the environmental impact of the component and the quality of given data. An exception is guidelines, which provide assessments and do not require specialist knowledge, provided that the user is willing to accept the judgement and values of the developer. Guidelines reflect the knowledge and the

opinions at the time when they are drawn up and may not be valid after some time. Guidelines also inhibit limitations of different bases of decisions that they are made of.

Table 1 Bases of decisions in different life cycle phases

	Used in phases	Content	Data	Critical review
Guidelines	Planning; Design	General to specific advice (e.g. chemical substances, resources, human health); Different life cycle phases considered	• Qualitative, mainly • Quality: unknown	-
Chemical stop lists	Design; Construction	Human- and eco-toxicology, based on chemical databases of the National Chemicals Inspectorate	• Qualitative, quantitative (content) • Quality: -	Some of them has been reviewed, but they are quite similar
Safety data sheets	Construction - mainly; Design - sometimes; Planning - rarely	Safety rules for humans and the environment; Human- and ecotoxicology; Disposal information	• Qualitative, quantitative (content) • Quality: unknown About half of the reviewed data sheets are incorrect (Olsson, B., KemI)	Yes, by the National Chemical Inspectorate
Building product declarations	Construction - mainly; Design - sometimes; Planning - rarely	Chemical substances, raw materials, energy use, recycling and waste	• Qualitative, some quantitative, cradle-to-grave • Quality: unknown	No, but rarely made by trade associations
Type III	Planning to construction	Potential environmental impacts	• Quantitative (cradle-to-gate), Qualitative (gate-to-grave) • Quality: varies	Yes
LCA/LCI databases	Program and design - mainly	Raw material depletion, energy use, emissions; Potential env. impact	• Quantitative, cradle-to-gate/grave • Quality: varies	Yes

The bases of decisions listed in Table 1 are greatly lacking information concerning the usage phase with maintenance, emissions and influence on energy use. Statements about service life are generally very rough.

The transparency varies between the different decision bases. Safety data sheets are obliged to follow closely specified guidelines provided by regulations and building product declarations contain more information compared to one year ago. However, all desired declarations in a project are not yet readily available and many are incomplete. Furthermore, it is not possible to compare different materials serving the same functions in a completely fair way as, for instance, system boundaries and allocation principles are not declared. However, by the action plan of the Ecocycle Council for the Building Sector and in the template for building product declarations, it is emphasized that the whole life cycle is essential to take into consideration when building products are chosen (BYKR, 1995, 2000). Type III environmental declarations, which are more transparent than building product declarations as they are based on LCA, are still rare. They are not frequently requested by consultants and manufacturers consider them too expensive to draw up.

Improved availability and quality of data are often emphasised. SETAC-Europe (2001) has identified a need of further standardisation of data communication for building components. It is critical that results are communicated in enough detail to make clear whether one study is truly comparable to another. The SETAC report states that easy-to-read and easy-to-use LCA-based production information is (at least in the building and construction sector) still in its infancy.

3.3 Impact Assessment

In general, consultants focus on different aspects when they assess different types of products. The assessment of products like floor coverings, sealing compounds and paint are mainly based on contents of chemical substances and human health. However, contents of chemical substances are declared with their potential impact on ecosystem and human health. The real impacts of the chemical substances on the environment, if they are emitted, are not always taken into account in the decision bases. The actual effect of emitted substances depends on several factors, but, by referring to the Environmental Code with its precautionary and substitutionary principles, consultants claim the right to avoid all components that contain some specified chemical substances. If the actual risk of the substances is to be estimated, a risk assessment is necessary. Assessments of framework material like concrete and steel are mainly dependent on the resource depletion and to some extent the energy use from cradle-to-gate. Only a few consultants estimate the energy use during the usage phase, on condition that the building elements are known.

3.4 Cost and Technical Functionality

Normally, environmental consultants are not asked to compare costs between different alternatives and they do not know the cost limits. However, combined assessments based on both cost and ecology are frequently asked for. In 1999 the National Board of Housing, Building and Planning declared that the building sector has to change its short perspective for investments to a long perspective. Environmental concerns are then expected to prove to be economically beneficial. A life cycle cost (LCC) perspective is asked for and is actually under development in a new standard, ISO 15686-5 (ISO, 2000b).

The environmental consultant's recommendation of a building component does not include an elaborate assessment of technical functionality. Mainly, the designer or the contractor assesses whether the technical functionality is met by the proposed component. However, recommendations at a higher system level (framework system and building elements) are based on experience and, therefore, include considerations of technical functionality to a higher degree.

4. DISCUSSION AND CONCLUSIONS

The study shows that different environmental consultants influence choices of building components at different system levels and in different phases of the project. The conclusions about the design phase are supported by contacts with Dahlgren and Eriksson for a housing project of Familjebostäder in Stockholm. From all the criticism about weaknesses in the bases of consultants' decisions, the reader could get the impression that these bases are of limited value. However, the use of building product declarations together with other bases of decisions are a positive step towards achieving agreements in the building sector on which environmental impacts are important to declare and reduce. They can also give the consultant much valuable qualitative information about how the material impacts the environment and human health. Today, decisions are mainly based on the content of chemical compounds and

the use of natural resources. From a life cycle perspective the energy use in the usage phase is very important. However, only a few environmental consultants use a method where this energy use is calculated.

In order to avoid suboptimisations numerous improvements must be made, some of them demanding further research. Some important improvements are as follows:

- Improved tools for assessment of building components are needed, including service life aspects, technical functionality, cost and methods to fulfil laws and regulations.
- Risk assessments of chemicals and, thereby, chemical experts are needed.
- A common LCI database should be set up with quantitative data, including impacts of chemical substances on human health and ecosystem.
- The importance of building context has to be recognized and considered more seriously.
- Improved guidelines to use when building product declarations are worked out.

To avoid suboptimisations there is a need of improved principles for building product declarations. The main needs are agreements upon allocation rules, definitions of system boundaries and functional units. There is also a need of more quantitative data for all the life cycle phases. Fossdal (1999) has described a method, where Type II environmental declarations were divided into two levels. The first level should contain only quantitative information. The second level was proposed to include quantitative data similar to the Type III environmental declarations but should not be based on the same requirements and would, therefore, be less time consuming to perform. The building sector in Sweden may now be ready for this type of declarations. However, there is a risk that they will still leave many questions unanswered and render impossible comparisons of components. A solution would be to wait for the ongoing work of ISO/TC59/SC3/WG12, which is developing an ISO-standard for environmental declaration of building products. The provided guidelines will be based on the ISO-standards for LCA and environmental labels and declarations. The declarations will include consideration of the products service life, environmental impacts of needed ancillary products, emissions to indoor environment and as an optional element normalisation and weighting of impact categories. However, manufacturers must see this type of declaration as a tool for product development and marketing. Only then could the cost for the extensive need of data be generally accepted.

Risk assessment of chemicals is a scientific field of its own, but with elements of trans-science in interpretation and assessment of test results. It would be useful to have more chemists in the building material industry. Together with the knowledge of manufacturers and contractors about the possible environmental impacts on the materials, they could help the industry to identify possible chemical reactions and improve guidelines for material and component combinations. By risk assessment of chemicals, consequences and their probabilities could be identified for emissions influencing the environment and human health.

The building sector in Sweden has taken several steps towards an ecological sustainable society, where the commitment to drawing up building product declarations and the environmental requirements in projects have increased the awareness in the building sector of the environmental problems. However, the working methods of environmental consultants and their bases for decisions have been the same during the last years. There is a need to refine existing tools for assessment of building components and to provide more quantitative data concerning environmental impacts during the whole life cycle.

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- Therese Malm, 26.02.2002, J&W (consultants)

Air Conditioning Absorption Systems for Office Buildings In Mediterranean Climate

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1. INTRODUCTION

Interest in absorption systems is growing up in these last years because of a new environmental consciousness, linked to a considerable increase in pollution on one side, and on the other to an always greater demand charges for electricity. The restriction in the use of CFCs, moreover, due to the depletion of the ozone layer, can represent a serious penalisation for vapour compression systems, still rulers of the market, especially considering air conditioning systems for non residential and industrial applications. All these factors led to a renewed interest and can lead to a more important role of absorption machines, if it will be possible to improve their performances, by analysing new working fluids, as far as new advanced cycles, and to reduce costs.

Although it can be theoretically considered environmentally benign for what concerns the working fluid and the insignificant amount of electrical energy necessary to operate, it is not environmentally friendly because of its large thermal energy consumption. Commercially available absorption systems in fact generally use as high temperature heat sources the same fuels normally utilised for thermal machines. Comparing the performances of these absorption systems with compression ones, it can be seen that the overall energy efficiency related to the primary source of energy is not appreciably different. Therefore, the use of absorption systems fed by fossil fuels doesn't seem to be a valid change in the use of energy sources.

Absorption technology instead will give a significant contribution to energy savings if used with low temperature sources, such as waste heat from cogeneration or industrial plants and solar panels. Specifically, solar energy is a particularly attractive application for air conditioning because of the near coincidence of the available solar power with peak cooling loads and at the same time, it is a solution to energise absorption systems reducing hydrocarbon combustion, thus improving environmental impact. This is especially true in Mediterranean climate, where this renewable source is abundant, even if these systems must be however supported by conventional sources of energy; it can be then discussed if it is better a heating or refrigerating help for obtaining better energetic/exergetic and environmentally optimal working conditions. However, environment improvements due to solar assisted cooling are directly connected to solar fraction.

Studies on methods to optimise the performances of absorption systems fed by low temperature heat sources, followed mainly two ways, that is research on new working fluids and analysis of complex cycles. A panoramic on absorption systems is presented in Srikhirin *et al.* (2001), in which it is provided basic background and review existing literatures on absorption refrigeration technologies, and several systems and research options are discussed; a more specific panoramic on technology development in the solar assisted absorption air conditioning systems is analysed in Li and Sumathy (2000). Recent bibliography presents moreover specific analysis on thermodynamic cycles, as demonstrated by the works of Perez-

Blanco (1993), concerning "Conceptual design of a high efficiency absorption cooling cycle", Felli and Galli (1983), whose aim was a thermodynamic study on absorption complex systems, and De Santoli *et al.* (1990) on the evaluation of the steady state performance of a two-stage absorption refrigerator. Interesting analysis for the development of this paper also the ones by Ziegler and Alefeld (1987) and Cheung *et al.* (1996) on multistage absorption cycles.
This paper is a development of the study proposed by Bisegna and Vallati (2001) on the possibility to use absorption systems and alternative energy sources for the air conditioning of non residential buildings in Mediterranean climate. It's the purpose of this work to compare single and two stage absorption systems to verify the chance and suitability of utilising together absorption systems and renewable energy sources, specifically solar energy; the aim is to find out the best system for this kind of solution by analysing COP and T_g (generator temperature) for different absorption cycles varying refrigerant flow and external refrigeration for several Italian cities characterising Mediterranean climate.

2. PRELIMINARY CYCLES ANALYSIS

In this study there have been considered a one stage and a two stage LiBr-water absorption systems. As known, the number of the stages characterises the number of basic absorption cycles that are combined to create a specific configuration, while the number of effects individuates how often a major portion of the driving heat is reused within the system to provide cooling. So, an increase of the number of effects means an increase of efficiency, while an increase of the stages, to which is linked the possibility to raise the number of effects, causes a rise of the complexity of the system.
A single effect absorption refrigeration system is the simplest and most common (Figure1).

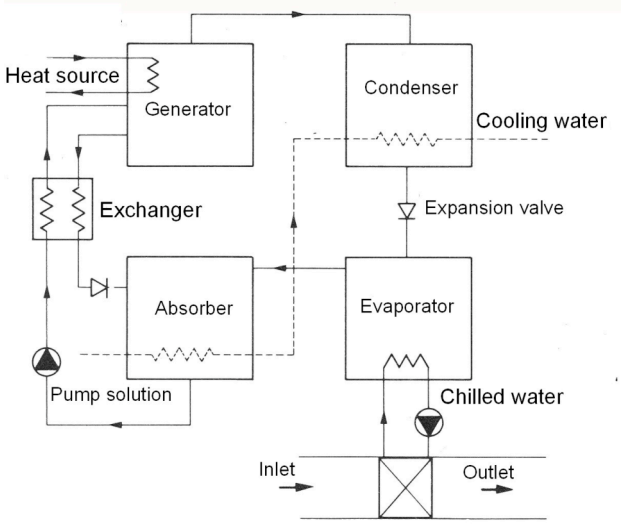

Figure 1. Schematic description of a one stage absorption refrigeration system.

The machine receives heat Q_G from the outside at the generator (G) at relatively high temperature; this is used to evaporate the refrigerant out from the solution and to heat the solution from the absorber temperature. The refrigerant vapour is then transferred to the condenser (C), where it condenses with Q_C heat rejected, while the solution flows back to the absorber (A) via the solution heat exchanger, whose aim is to pre-heat the solution rich in refrigerant before entering G by using the heat from the hot solution leaving G, and a throttling valve. Similarly, the liquid refrigerant condensed in C via a throttling valve is transferred to the evaporator (E). In E heat from the load, Q_E, evaporates the refrigerant, which recombines with the solution in A, by rejecting Q_A. The solution, now rich in

refrigerant, returns back to G, via a pump and heat exchanger. So, G operates at a higher temperature, while to lowest-temperature element is E, where there is the refrigeration effect.
The way of working of the two stage absorption system (Figure2) instead is the following: H_2O-LiBr solution evaporated from G to concentrate the solution is then transferred to C. Here it condenses, and the result is pure refrigerant. In this system, C and G mass flows are about the double in respect to a normal one stage system.
After passing EV, pure refrigerant follows two different ways, representing the two stages of the absorption system: a low pressure stage, cooled by a high pressure E, and a high pressure one, cooled by the external refrigeration fluid.

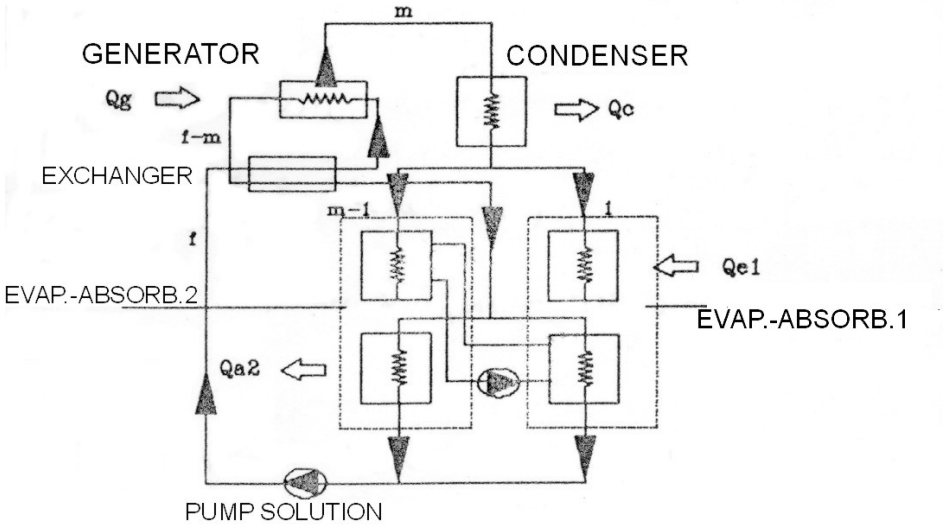

Figure 2. Schematic description of a two stage absorption system.

3. CALCULATION HYPOTHESIS AND METHODOLOGY

Two different calculation methods have been used, the first one to evaluate the hourly thermal loads of the building, by the use of an integrated energy simulation, the second one, basing on the these outputs, to analyse absorption system behaviour.
The request for a quick performance evaluation of the thermal loads is resolved with the non-commercial program IENUS (Integrated ENergy Use Simulation) (Gugliermetti *et al.*, 2000 a, b), that is mainly a dynamic heat transfer model incorporating several modules to simulate the management of the visual environment. Once known thermal and hygrometric loads, another calculation model, developing a finite time thermodynamic analysis, has been used to evaluate absorption systems' performances. Specifically, the generator temperature T_g is a function of the working fluid temperature in C, E, and A definitely determinable when solution equation or P-T-X diagram are known. So, once fixed T_e, T_c, T_a, of the intermediate fluids, T_g is a function of only one temperature interval, i.e. ΔT_e. By this weay, it is possible to know T_g and COP trends, and exergetic performances of the absorption system when varying hourly thermal loads and process variables.
Attention has been focused on the thermodynamic behaviour of an absorption system for air conditioning a non residential building, whom total volume is up to 4200 m^3. It is composed of 4 floors, each one characterised by office rooms, dimensions 7x5x3 m, overlooking a central passage. Windows' orientations are South and North; every window is 3.0x2.0 m^2 and it is displaced 1.8 m above the floor, recessed 0.1 m and centred respect to the external wall surface. There is a window per room, with no overhangs. Room furnishing is ordinary, with no carpets. Thermal transmittance of the wall is up to 0.8 W/(m^2 K), 1.8 W/(m^2K) for the window; the envelope construction weight is about 200 kg/m^2 of floor. Every surface is considered lambertian, with visible reflectances up to 50% for the internal walls, 20% for the floor and 80% for the ceiling. Internal shear curtain characteristics are the shading coefficient

(SC) of about 0.4 and the visible normal-normal transparency of 0.5; the direct light transmitted diffusely is up to 0.1. Other aspects characterising each office room are:

- people occupancy: 3 office workers everyday from 8.00 A.M. to 20.00 P.M. during all the summer period;
- people sensible and latent heat: 50 W/p (50% radiative, 50% convective) and 40 W/p;
- artificial light and equipment: 800 W of standard equipment and 600 W of fluorescent lamps with recessed, not vented fixtures, from 8.00 A.M. to 20.00 P.M., when it is required by system control. Illuminance on the working plane (0.8 m) is fixed to 500 lux;
- HVAC: primary air and fan-coils, running everyday from 6.00 A.M. to 21.00 P.M.;
- thermostat throttling range: 1 °C.

One and two stage LiBr-water absorption chillers with heat exchangers' efficiencies up to 0.7 have been considered; several intermediate fluid flows have been assumed. McNeely's data (McNeely, 1979) have been utilised to describe solution's thermodynamic properties.

4. RESULTS

The analysis was first developed for the city of Rome, with the aim to test the two different thermodynamic cycles and absorption machines varying the mass flows of the internal elements (Pa, Pe, Pc, Pg), once fixed the other parameters: Figure 3 shows for both the one and two stage absorption systems a decrease of TGO when increasing the mass flows.

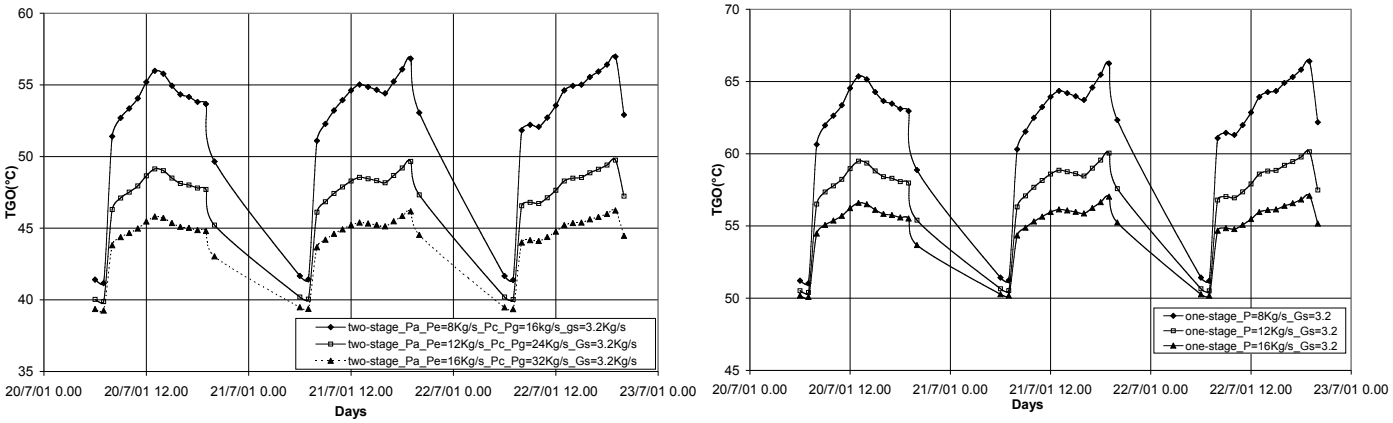

Figure 3. TGO trend with several mass flows for two and single stage absorption systems.

The selection of real machines is so based only upon constructive needs: it is in fact clear that it is impossible to realise systems with infinite mass flows. This remark led to the selection of real machines characterised by internal mass flows of 8 kg/s for the one stage absorption system, and of 8 kg/s and 16 kg/s respectively in E-A and in C-G for the two stage one.

The following step was to evaluate TGO trend when varying the recirculating mass flow (Gs); the result showed in Figure 4 for the two stage system is that a decrease of this mass flow causes a decrease of TGO and an increase of COP. The comparison of the two thermodynamic cycles was then developed with a recirculating mass flow of 2.2 kg/s.

Once defined the two absorption systems, it was interesting to study their performances with two different refrigeration temperatures, specifically 27°C (that is water coming from cooling tower) and 35°C (that is external air temperature in the summer period). Figure 5 and Figure 6 show the better behaviour of the two stage absorption cycle in terms of TGO and COP in respect to the one stage, although both the systems present a decrease of this parameter.

What is really interesting is that the higher is the temperature of the refrigerating fluid, the higher is the gap between the TGOs of the two systems, in favour of the two stage. From the COP point of view, representing the energy performance of the system, one stage is always better than the two stage.

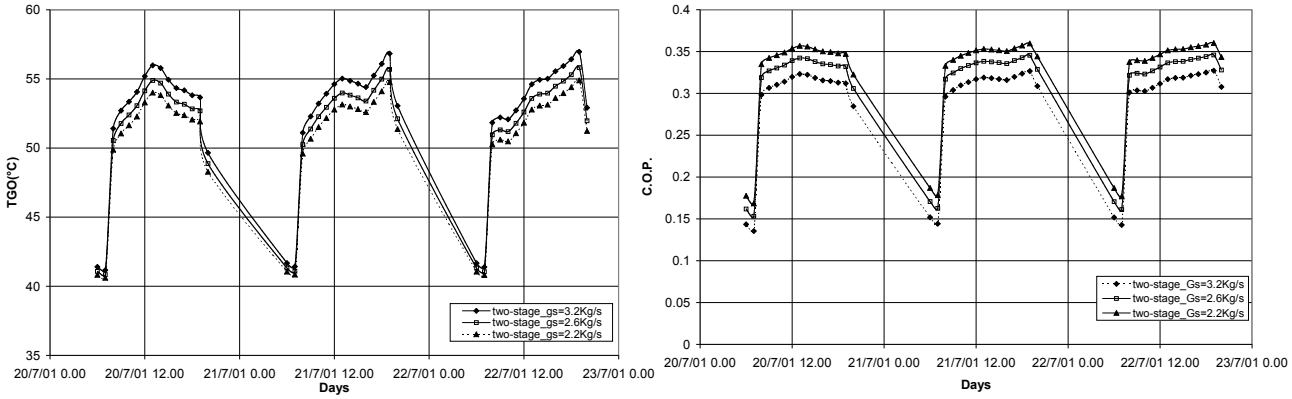

Figure 4. TGO and COP for the two stage system for several recirculating mass flows.

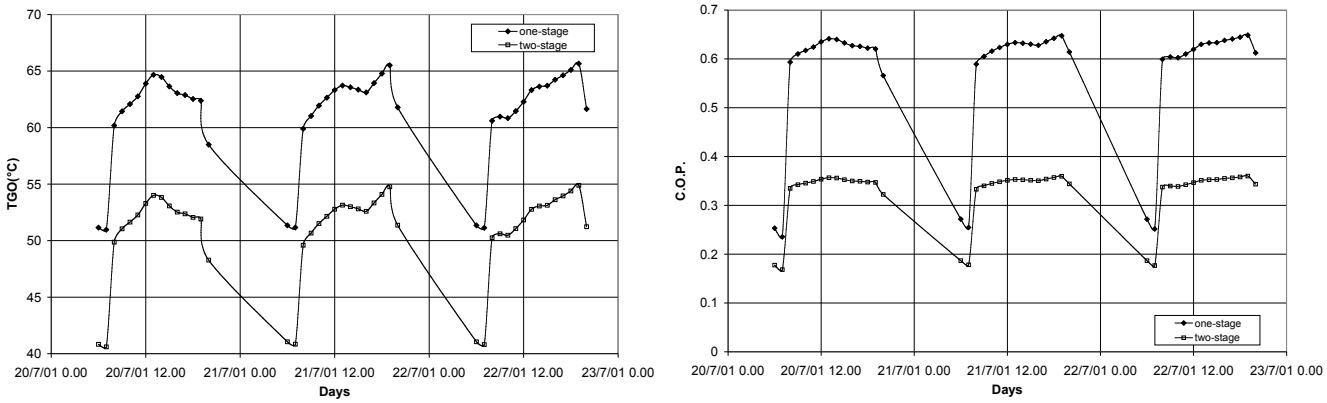

Figure 5. TGO and COP for single and two stage systems, 27°C refrigerant temperature.

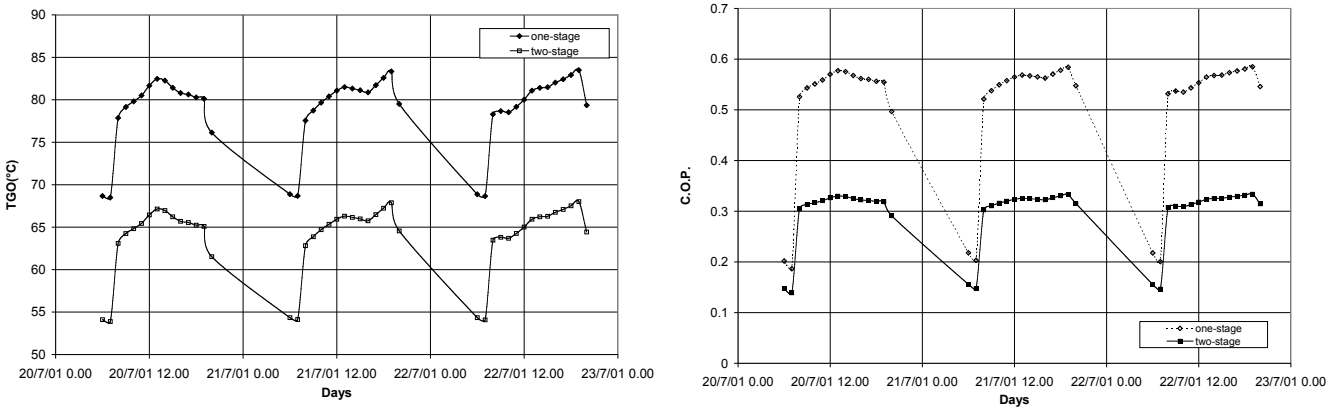

Figure 6. TGO and COP for single and two stage systems, 35°C refrigerant temperature.

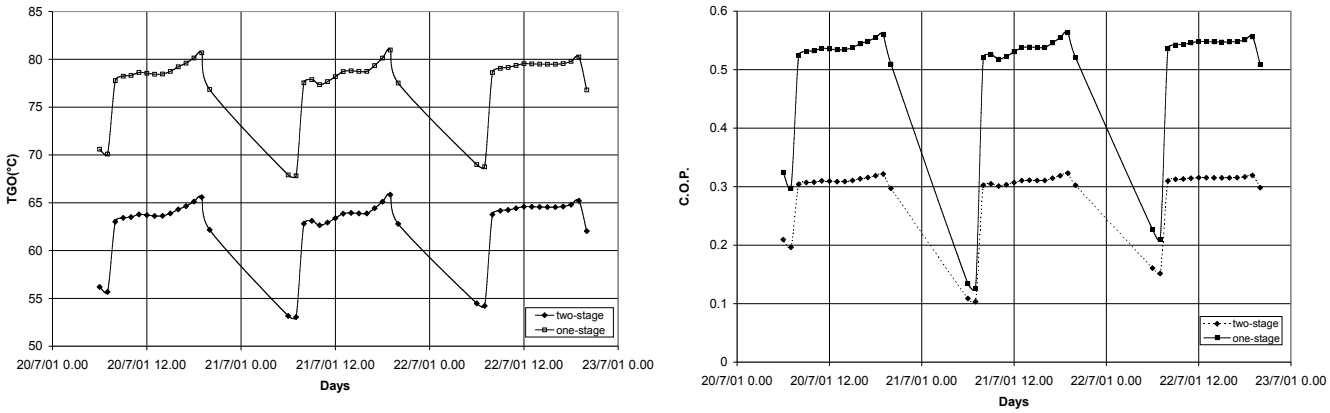

Figure 7. TGO and COP for a two stage absorption system in Messina.

Similar results are obtained for several latitudes characterising the Mediterranean climate; Figure 7 shows the situation of Messina (38°) for a single and a two stage real absorption system working with a refrigeration temperature of 35°C.

5. CONCLUSIONS

This paper presents a comparison, in terms of TGO and COP, between a series of single and two stage absorption systems for the air conditioning of non residential buildings in Mediterranean climate to test the possibility to use absorption systems and alternative energy sources, specifically solar energy, together. Results showed the always better TGO performances of the two stage absorption system in respect to the single stage in spite of energy performance results; moreover, the higher is the temperature of refrigeration, the lower is especially the two stage TGO, and so the greater is the gap between the TGOs of the two systems. This means that if we accept a lower energy performance, we can obtain a lower TGO, that is an absorption system fed by a relatively low temperature heat sources, such as waste heat from cogeneration or industrial plants and solar panels; this can be considered as a great result for climates, just like the Mediterranean, where solar energy is abundant, and so it can signify a sensible contribution to energy savings and a real improvement in terms of environmental impact. An operative proposal will must consider now the introduction of several types of solar collectors and energy storage dimensions for both single and two stage systems for Mediterranean climate to individuate the best kind of system, in terms of both energy performances and environmental impact, for Italian latitudes.

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Overcoming the Barriers to the Greater Development and Use of Environmentally Friendly Construction Materials

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1. INTRODUCTION

1.1 Green Building Materials and Products, Sustainable Construction and the Environment

With buildings and a building industry responsible for major environmental damage (Woolley1990), sustainable construction is fundamental to the wider environmental debate. Yet it is often set aside: ignored by environmental groups and not taken seriously by the construction sector. Most research –whether academic, industry or government led revolves around energy issues, and little is said about the importance of indoor air quality or the impact of the choice of building materials on the environment. As buildings become increasingly energy efficient, however, the current balanced will however beginning to change and more focus will be placed on embodied energy and subsequently on green building materials and products.

As a result of the growing interest in sustainable construction from clients, architects and government policy, many building materials and products are being offered as environmentally friendly. Other products have been specifically developed to meet the demand for 'green' sustainable materials. Yet it remains essentially a pioneering sector, dealing with a 'niche' market. In other European counties, such as Germany, green materials have a small but significant market share and many of the green products available in the UK are imported from Germany.

1.2 Aim and Background of the Research

In order to examine how green materials can be widely used, it is necessary to define the nature of green products in both manufacturing, distribution, installation and demolition. The research also examines the process of decision making by purchasers to assess to what extent their choice of material and products is based on economics, performance and environmental issues.

Because the research was a one-year pilot scheme, funded by the UK Government Engineering and Physical Sciences Research Council (EPSRC). We have carried out in-depth interviews with industrial partners and organised a seminar to discuss our results. We have looked at examples of how green materials have been used, and allow us to examine the reasons why they are (or aren't) being specified on projects. We have also met with a range of actors and organised focus group discussions to stimulate debate and obtain feedback on our findings.

1.3 Industrial Partners

We are working with six industrial partners. (Table 1) These companies deal with very different products and come from varied personal histories. Some would present themselves as ethical

companies and came to environmental construction from a political and ideological angle; others have an industrial background and grew concerned with health and safety regulations

- AAC Waterproofing Ltd./Prelasti:
  Based in North Wales (Anglesey), Prelasti produce EPDM roofing material (rubber based waterproof membrane for flat roofs, pond lining, etc.) http://www.prelasti.demon.co.uk/

- Green Building Store / Environmental Construction Products:
  Based in Huddersfield in Yorkshire, the Green Building Store has a dual function:
  They produce their own brand of high performance, environmentally friendly windows, doors and conservatories. The store (and on-line store) is also selling a range of related products (paints, varnishes, etc.) http://www.greenbuildingstore.co.uk/

- Solar Twin Ltd.:
  Company based in Chester. They produce and sell freeze-tolerant solar water heating system with integral solar-electric (photovoltaic) pump http://www.solartwin.com/

- Bio-bubble Ltd.:
  Located in South England in Emsworth, Bio-bubble conceive, install and maintain a waste water and sludge treatment plant using Sequencing Batch Reactor technology http://www.bio-bubble.com/

- Eco Solutions Ltd.:
  Eco solution patented an environmentally friendly/safe water-based paint stripper. Their range of procduct is sold from their North Somerset base as well as through more mainstream retail outlets around the country. http://www.ecosolutions.co.uk/

- NTB - Natural Building Technologies:
  Retail outlet as well as construction company, and technical advice service provider. They sell Earth and lime products; insulation material; timber; natural paints, etc. The company is based in High Wycombe. http://www.natural-buildings.co.uk/

2- POLITICAL AND CULTURAL FACTORS INFLUENCING THE DEVELOPMENT OF GREEN BUILDING MATERIALS AND PRODUCTS

2.1 Government's Policies and Priorities

The current UK policies on sustainable construction have largely been influenced by the 'Egan report' (DETR, 1998) which focussed on the management of the construction process and paid little attention to environmental issues, and "Building a Better Quality of Life" (DETR, 2000) which had its environmental policies watered down.

Most construction R&D work carried out at the Building Research Establishment (BRE) and Construction Industry Research and Information Association (CIRIA) has focussed on environmental rating systems and the assessment of generic materials. Little of this has been directly useful to our industrial partners as it does not deal with specific products so we are planning a joint research project which will build on some of the issues identified in our research.

Our study points to the need for more independent research. The recent 'Fairclough report' (DTI, 2002) on R&D in the UK construction sector has identified the need for a greater range of independent research. At present the vast majority of work reflects the vested interests of large national and multi-national corporations.

Legislation was identified throughout our interviews as *the* single most important potential source of change. A range of both positive and negative measures would substantially affect the current situation and could promote green building materials and products, for instance:

- Stronger public sector *green procurement and purchasing policies* at national and local levels. At present these largely concentrate on soft areas like paper rather than buildings.
- Legislative changes to encourage 'best-value' rather than lowest price contracts.
- Legislative changes to *allow specification* from government agencies
- *Setting of standards* for a wide range of materials. limiting pollution and toxicity levels
- Introduction of *financial incentives* to boost production of green building materials and products (E.g. lower VAT, subsidies, etc.)
- *General policy* measures, e.g. the inclusion of sustainable construction as a subject matter in schools of architecture and the introduction of sustainability in the curriculum…

2.2 Interest and Perceptions from the General Public

Public opinion, and subsequently consumer demand, appears as the second most important source of potential change.

There appears to be a low level of public awareness of environmental issues in the construction sector in the UK. This is surprising there has been a huge expansion in demand for organic food. There is a suspicion of innovative materials when associated with property investments and the demand for traditional homes. Popular folklore supports myths that green materials are more expensive and not as good as conventional ones. Most SMEs are unable to finance market research though they all have a great deal of anecdotal feedback from their customers.

The influence of both the media and environmental pressure groups on public attitudes can be significant. The media tend to focus on unusual things like strawbale buildings while also promoting questionable materials such as MDF. Environmental groups, comparably, tend to tackle single issues such as uPCV or tropical hardwood. While the Forest Stewardship Council (FSC) has attracted support from a celebrity figure, Pierce Brosnan (James Bond), there are few high profile supporters of green building as a whole.

2.3 Need to Lobby Policy Makers

Another issue to emerge from the research is the limited opportunities to influence government action. A number of key agencies have the possibility to change governmental and public attitudes ranging from professional bodies to housing associations but little is being done.

Demonstration projects seem to be one of the most effective ways of drawing green building ideas to the attention of the above agencies. We have compiled a database of claimed sustainable building projects in the UK and tried to identify the extent to which these products have incorporated green building materials and products. One such project, BEDZED, has attracted a considerable amount of media interest and has shown that, despite its innovative nature, it has had no difficulty in attracting customers to buy the houses.

2.4 Legislation, influence and examples outside the UK

The adoption of progressive policies in Brussels and Strasbourg has forced green issues onto the UK agenda. The Construction Products Directive may push manufacturers to address issues which they have so far been able to ignore. Given the increasing globalisation of the ownership of virgin material resources and manufacturing, environmental standards need to be international.

3. WHAT ARE GREEN BUILDING MATERIALS AND HOW 'GREENNESS' CAN BE ASSESSED?

A wide range of building materials and products are now being offered as 'environmentally friendly', less polluting, more energy efficient, less wasteful of non-renewable resources and less damaging to health. We have tried to review the criterion for substantiating green claims for building products including environmental profiling, life cycle analysis, etc. Many established business are now making questionable environmental claims which causes confusion and undermines the credibility of products where genuine environmental improvements have been made. Given the lack of consensus on these issues it has created something of a 'free for all'.

All of our partners emphasise the importance of the green credentials of their product(s) for their clients. However, that relationship is based on 'trust', rather than on a particular method of environmental assessment. Generally customers seem willing to accept the claims often producers, but this close customer supplier relation of trust may not be appropriate in a wider market when larger customers will demand independent assessment of products.

3.1 Difficulties Associated with the British and European Accreditation / Assessment Systems

In the UK, much of environmental assessment thinking has been dominated by a narrow focus on energy efficiency and a limited concept of setting targets for completed new buildings. While BREEAM has served a useful purpose in raising awareness on energy efficiency, not enough attention has been paid to resource depletion, pollution and indoor air quality. Our SME partners get very little direct benefit from existing assessment systems. There is a lack of commonality in the criteria that are included leading to a current practice in the industry of cherry picking environmental gains which are easy and ignoring others which are inconvenient. A further outcome of the research has been to form a partnership with a range of organisations to analyse existing assessment systems in order to develop a simpler 'tool box' which allows building developers to make transparent environmental decisions about products, materials and building systems.

Some of our partners also identified wider difficulties when considering assessment methods. For some companies which would describe themselves as 'ethical', assessment methods would need to include physical, social and health considerations, controversial as these may be. They further deplore the lack of transparency and accountability of research institutions, consultants and other accreditation bodies who use so-called 'black-box' methods. Environmental Building News refers to these problems as the search for the 'Holy Grail'.

> "Problems arise concerning the quality, consistency and availability of data on products and processes; the methods used to compile inventories and especially the assumptions and systems used to translate inputs and outputs into measures of environmental impact" (EBN, 03-2002)

4- PRACTICAL DIFFICULTIES IN THE MARKET AND USE OF GREEN BUILDING MATERIALS AND PRODUCTS

Most obstacles to a greater uptake in this sector appear at a practical level. The argument most commonly used to justify resorting to traditional building products has to be the supposed higher cost of greener alternatives. Myth or reality, there are technical, financial and business difficulties to the development of green products for SMEs.

4.1 Producing and advertising green building materials

Difficulties in the marketing of green products prove a major obstacle. Our industrial partners described their niche market as the 'green ghetto'. Moving out of the 'ghetto' into mainstream is *vital*, not only for our partners' businesses but also, more importantly, for sustainable construction as a whole. Indeed, the construction industry will only become 'sustainable' when the vast majority of buildings follow sustainable methods and resort to sustainable products.

Marketing and getting specified are crucial issues. 'Greenness' can prove a difficult value to sell; Marketing difficulties also include competition. SMEs often battle against the mainstream industry and powerful multinationals. Patents and IPR require an important investment and can lead to expensive legal battles i.e. to a lot of difficulties for small businesses.

4.2 Specifying Green Building Materials

Getting support from committed green architects can make a significant difference for SMEs producing green building materials and products. Without a privileged relationship with a committed architect or contractor, the specifying process becomes much more difficult.

A close relationship with designers, specifiers and builders has been essential in developing the use of green products. However relying on the dogged perseverance of a few is not a basis for developing a wider market. One outcome of the research is that we plan to contribute to the development of the "National Green Specification' (NGS) which will create a full range of standards specification clauses for green materials and building methods.

4.3 Use of Green Building Materials

Despite the many problems identified in our research our SME partners have seen a steady rise in their business. A number of products are breaking out of the 'green ghetto' and getting onto the shelves of large builders merchants and DIY stores. For architects it can still be difficult to source them or get them used on site as building contractors frequently try to substitute more conventional products.

Very strong technical backup has also been identified by many as a prerequisite for the success of green building SMEs. Products can be complex and require new –or forgotten– techniques. Without a strong technical back up, contractors will refuse to embark on such an experience.

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Specifying Green Buildings
The owner-occupant's perspective

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1. INTRODUCTION

In the Canadian building industry, for both the design and construction, sustainable or green buildings are still perceived as a costly alternative to traditional design and construction.

Public sector organizations have to use a transparent process when contracting for design and construction work. Such processes demand that the organization clearly states its operational requirements with little room for preference and none for specific products, technology or innovation. It is therefore difficult to request particular products that are more sustainable or call for building features that may have no operational impact but important sustainability benefits.

2. PRESENT SITUATION

Investment analysis

In the Canadian federal Government, the investment analysis is where the first decisions are made. It is determined if the supply of space at their disposal meets current and future space demands. If construction is required, the projects are approved based on business cases developed according to pre-established ranking criteria. The approval or rejection is based on a list of weighted criteria established according to the individual organization's priorities. Health and safety, operational and financial considerations are normally those with the highest weighting. Environmental benefits are rarely considered unless there are obvious legislated deficiencies identified.

At this stage of the planning process there is no mechanism to put the future construction project on the path of being green. The analysis is purely financial and is based on traditional accounting practices. The traditional costing methodologies do not consider the kind/type/quality of accommodation options. A number of elements that are considered in a green building, such as occupant comfort and energy performance, have a very important impact on the total cost analysis but are not factored into the early decision making process.

Delivery approaches

In the public sector, when it is decided to build, the approaches to design and construction generally undertaken are:

Design, bid, build: In this traditional approach, the design team completes the design, plans and specification, which are then submitted to a public tender process. The general contractor with the lowest bid is awarded the construction contract. In this model, the selection of the design team and the mandate given to that design team is critical to achieving a green building. The

onus is therefore on the owner to perform an important preparatory work to influence the process, which means more time elapses before a design team is selected. This creates a strong perception of delays in the building project and is rarely accepted by the organization's senior management. Even with very good planning and design, the principle of the lowest bid puts a green project at risk.

Design-build (one or two stages): From a set of users requirements, a public tender is issued to carry the project from the user requirements into a building that is ready for occupancy. It generally requires the partnership of architects, engineers and construction firms. The selection of the team is based on a combination of price and capability. Similar to the above process, the owner is required to perform comprehensive preparatory work but it is understood that the design and construction stages will be shorter than in the design-bid-build approach. This approach is currently one with great potential to deliver a green building within the Canadian public sector. It will be explored in more details later.

Public-Private Partnership (P3): Similar to the design-build but the ownership is left with the private firm (developer) where the public sector organization is leasing the property for a long period. This is the most difficult approach to influence. The leasing agreement could, however, include terms that give incentives to the developer for designing and building a greener building.

Selection of design team

In the public sector, the design team is selected based on a number of criteria such as their experience in the kind of buildings the owner requires. Of course, the fee proposal plays an important role in the selection of the design team. In this competitive environment, architects and engineers are encouraged plan for the minimum design time possible. Fee proposal are also based on a percentage of construction cost rather than complexity and depth of design work required. The traditional design team does not lend itself to a green design unless the architect is one, of the few, who understand green buildings.

Contracting for construction

The selection of the construction contractor is normally a simple task of issuing a call for tender and giving the job to the lowest bidder. The lowest bidder may not have the trade skills to deliver a high quality building, like green building needs. Furthermore, the lowest bidder may not understand or be willing to have a waste diversion program during the construction.

3. PROPOSED SOLUTIONS

Despite the difficulties presented above, the public sector owner has the opportunity to influence the process to increase the chances of obtaining a green building. Potential solutions will be presented and those where the authors had experience will be highlighted.

Influencing the decision making process. In any organization, public or private, the capital expenditures are controlled at managerial levels far removed from those understanding building technologies and the holistic benefits of green buildings. Decision makers will not become environmentally sensitive overnight. Their tools, such as the investment analysis and the business case process have to be modified to highlight the financial benefits of green buildings.

Additional costs vs estimating inaccuracy. The C-2000 program demonstrated that the capital cost of those meeting its requirements varied between +7% and -15% compared to a Atraditional project. Decision makers must understand that the initial, budgetary estimates, which they use to make their decisions, are only 70% accurate. At this level of accuracy, the difference between a green and a traditional building is within the accuracy range. Often, an additional 10% for contingency during construction is added to the budget. This contingency is normally expended

for site conditions and design errors. Here again, decision-making tools, such as estimates, must be modified to reflect increased expenditure at the design, such as green design, without increased capital construction costs.

Life-cycle vs capital costs. In most public sector organization, the management of the funds for the capital investment and the funds for operating the buildings reside in different hands. This leads to short-term vision about investment. The investment analysis must take into consideration the full life-cycle cost to highlight most of the financial benefits of green buildings. Influence in the early stages of the investment decision will allow green building route to be followed later in the process. The business cases developed for each project have to include life-cycle cost of different Agreen performance@ options to make decision maker aware of the financial potential of green buildings.

Added operational benefits. As those involved in green buildings know, a green or sustainable building has benefits that are not easily quantifiable and therefore not included in the decision making process. More and more study show that elements such as natural ventilation, natural lighting and individual control of the workspace contribute to the increase in the performance of the occupants. Such benefits must be highlighted in the investment analysis to direct the project philosophy towards green buildings. The financial analysis tools such as the PVCOA can be modified to quantify the additional operational benefits as well as the full life-cycle analysis of green buildings such as lower energy costs.

Best Value principle. The traditional business wisdom of selecting the lowest cost proposal has proven time and time again that it does not provide the best solution to the owner. Not only to achieve the green building, but to obtain the best building to meet required needs. The principle of Abest value@ must be adhered to. No matter which project delivery approach is chosen, the selection of the team, that assist and surround the owner in the building project, must be based on selection criteria that goes beyond cost, and must rate the value that the team will bring to the organization.

The public sector must follow an open and transparent process, which means that the determination of value must be based on very objective criteria. In our society, it means numbers. We therefore require a point rating system which weights each criterion according to what we determine as being Avalue@ for the organization. It is where the owner can have a powerful influence in greening their buildings. In selecting the design team, more points can be awarded to those with experience in elements of green buildings such as those shown in point system of exhibit 1.

Cost is still a required element of the equation but it can be managed to become a minimal factor in the team selection process. It can be used to select between those that have achieved the Apass mark@ in the points evaluation as long as the pass mark is set high enough. The cost can also be fixed according to a pre-determined life-cycle budget. The selected team is therefore the one that can deliver the best project within the prescribed budget. This fixed budget must nevertheless be based on careful life cycle cost analysis.

The case study presented below illustrates how the best value can be applied and what should be avoided.

Standards vs Specification

As expressed above, the owner has the largest influence in the early stages of the project. The investment analysis, the business cases, the building requirements or even in the selection of the design team, the owner is heavily involved in establishing the proper foundations to achieving a

green building. From the building/user requirements all the way to the shop drawings, elements of the building are specified. The description of the green buildings is expressed in more and more details through these specifications. From an owner=s perspective, a number of standards must be respected but when it comes to the detailed specifications, the owner has to decide how to enhance the chances to obtain a green building.

Technology, practices, standards and codes change constantly. Is the owner occupant capable to keep track of all the changes that will lead to the best and greenest building? Can an owner occupant add value to the specification process by being prescriptive? The experience with green buildings leads us to believe that the answer to both of the above is Ano@. Standards must be related to the occupant=s functions and purpose for the building and not get involved with specifying details. Standards and specifications defined by the owner must performance based to allow the best value, green building to be derived from design and construction process.

Performance standards based on existing green buildings tools such as GBTool, LEEDS and BREEAM can be used in early documents to drive the design team to use their experience, knowledge and innovative skills to meet the owner=s performance challenge.

Architects and Engineer's fees for best value
Selection of design team should be based on the talent, skills and experience relevant to the building the organization want delivered. Fees should be based on accepted professional association=s guidelines and the number of hours expected to deliver the project, according to the services sought by the owner. A green building requires to be optimized; the design phase need to follow an iterative process and the allocated time must be flexible.

Architect, engineers and constructor collaboration
It has been demonstrated in the green buildings field that an integration of all the discipline involved is necessary to achieving a successful project. It is difficult to mandate collaboration but the owner can establish contractual arrangements to encourage the collaboration. The inclusion of a green design facilitator has shown benefits from greening design.

4. CASE STUDY

Context
The Royal Canadian Mounted Police (RCMP) has a requirement to build new office space to be used as swing space for a multi-year renovation project on its Ottawa headquarters campus. The building, approximately 5 800 m^2 in floor area, will involve three floors of office space and an atrium, to be built over the southern half of an underground computer facility which forms part of an existing building.

Since the user requirements were calling for simple open space plan office, the RCMP wanted to stay away from the detailed design and handed the project over to PWGSC for delivery. Furthermore, the RCMP wanted to obtain a building in the shortest timeframe possible. Sustainability was not a consideration in this project at that stage. The project cost was estimated at CA$10M.

Project delivery
The delivery method chosen was the Design-build. The RCMP=s Environmental Management & Technical Standards section put repeated pressure on the owner=s project team to green this project. Initial reaction from other stakeholders had been very negative, as it was feared that any greening criteria would slow down the project and increase the costs.

In the RCMP project, a two-stage approach was used. The first stage, screening, called for proponents to submit the team credential including experience in green design. From those received, the four proponents scoring the highest against the evaluation criteria were funded to submit a design and cost proposal. The request for proposal (RFP) was open to any proponent but due to the extensive nature of the requirements, only three of the funded firms and no others chose to submit a proposal.

The RFP contained a 19-page sustainable development section was developed by Lyse Tremblay, Architecte of Montréal while the construction waste criteria were developed by byDesign consultants of Ottawa.

The rating of the sustainability criteria accounted for 26% of the total technical score. Exhibit 1 lists the criteria used for the rating: The other components of the score were: Project management the architectural merit. This was a 2-envelope proposal: one contains the technical proposal and the other the price. It is the transparent method to ensure that the technical evaluation is solely based on the technical merit and not influenced by the price. Proponents not reaching the pass mark would be rejected before the price proposal envelope would be opened

The cost proposal was then divided by the total score obtained by each proponent to obtain a Aprice per point@ rating. The lowest cost per point was then awarded the contract.

What happened?
Two of the three proponent took the sustainability criteria very seriously and submitted proposals that could have made this building one of the Agreenest@ in Canada. In the sustainability criteria one proponent rated very high while one failed. Failing on any section did not eliminate a proponent. Even failing to meet specified objectives did not, by the terms of the RFP, result in elimination from the process. In this case, one proponent did not even meet the 25% energy reduction requirement. At the end, the cost proposal of the proponent with the lowest technical score was so much lower than the two others that he was awarded the contract; unfortunately, this was the one that did not meet the 25% energy reduction.

Lessons learned
In a design-build rating system, to obtain the best building possible, the technical merit weighting must, by far, outweigh the initial cost aspect. The total life-cycle cost must be the cost criterion. Performance requirements that are deemed to be essential to the achievement of the building=s goals must be, on their own, criteria for elimination from the selection process.

5. CONCLUSION

From the owner-occupant role, the decision making, contracting and design processes lend themselves to be influenced and modified to enhance the chances of delivering a green building for the. Influence at the investment analysis can demonstrate that there are great cost benefits in planning for a green building. The selection of the design team is another opportunity for an owner to ensure that a green, efficient building is delivered. From the owner=s perspective, performance criteria should be used instead of prescriptive design specifications to allow for innovation to emerge from the design team.

Finally, it is believed that the design-build process is the delivery method that currently offers a great green building potential for owner-occupants or public service organizations.

Exhibit 1 - Rating table

		Max Pts
Energy Efficiency		
	Mechanical building system	25
	Electrical Building System	20
	Architectural, structure & envelope	15
	Renewable energy strategies	10
Occupant comfort and Productivity		
	Indoor air quality	15
	Lighting quality	10
	Thermal quality	10
	Acoustic quality	10
	Optimal Space Quality	5

Reduction of Environmental impact		
	Optimal use of site resources	10
	Materials and products	10
	Reduction of polluting substances	5
	Enhancement of site microclimate	5
	Irrigation & rain water recovery	5
	Control of storm water	5
Low water consumption		20
Low O&M and life-cycle costs		
	Mechanical system	25
	Electrical system	15
	Low maintenance requirements	10
Waste Management Strategies		
	Waste diversion in construction	10
	Design for disassembly	10
	Design for occupancy wastes	10
	TOTAL	260

Development and Implementation of Sustainable Micro-Utility Infrastructure

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INTRODUCTION

Historically, infrastructure was developed under a communal mandate. As a result, infrastructure expansion and service connection for new dwellings or industries solely focused on the development of large scale, grid-based "macro" systems. The micro-utility approach deliberately de-couples individual infrastructure from communal infrastructure. It implements a complete integration of the individual dwelling or dwelling clusters with appropriate micro-infrastructure into a self-sufficient, energy efficient stand-alone module. The user of the micro-infrastructure becomes at the same time, the provider of the infrastructure. This fosters increased technology awareness and allows the consumer to participate more actively in the development of novel integration and conservation strategies – directed by individual awareness and site-specific requirements rather than large scale outside design parameters.

myname
Kommentar:

To be successful, the integration of micro-infrastructure technology has to be effortless, transparent and convenient for the user / supplier. The consumer must be able to utilize the self-contained utility appliance in exactly the same way as the conventional grid-based infrastructure. In an effort to investigate and develop manufactured micro-infrastructure solutions, a novel, eco-appropriate solution, the "*EcoNomad*" was designed, prototyped and is presently undergoing in-situ testing.

For several years, Canada Mortgage and Housing Corporation (CMHC) has worked on the advancement of site-specific micro-infrastructure solutions. In 1995, the "*Toronto Healthy House*" was constructed in the heart of urban Toronto, showcasing a single-family dwelling unplugged from the conventional utility grid (Ives et al, 1996).
The present project builds on the "Toronto Healthy House" experience and continues the goal of seamless integration of on-site micro-utility, with an energy and resource efficient building envelope and a healthy eco-aware living space, but in a remote northern community.



Figure1: Installed in August 2000, the micro-utility equipment housed in the combined mechanical utilities container (center, 160 sqft/15 m^2) supplies all infrastructure and utilities for the 1152 sq. ft. (107 m^2) dwelling. The dwelling (left) is not connected to the central utility grid.

An important motivation in the development of alternatives to conventional utilities is the very high cost of providing grid-based infrastructure in the northern communities of rural Canada. The Ministry of Indian and Northern Affaires (2000) reports typical costs of a central community grid-based power connection, including potable water and sewage, to be in the range of $ CAD 80,000 per single-family dwelling. In some cases, costs have been reported as high as $ CAD 180,000 per serviced dwelling. In most cases, the cost of providing grid-based utility servicing from central supply to the properties is higher than the cost of the dwelling construction itself.
The present system goes even further in that it provides not only the utilities, but also the full mechanical system of the building. To further reduce the cost of servicing, preference is given to the development of cluster applications. A 3-unit housing cluster can be serviced for a cost of $ CAD 45,000 per unit; detached single-family dwellings for a cost of $ CAD 85,000.

2. MICRO-INFRASTRUCTURE

2.1 Description of Existing Technology

The provision of utility conveniences -- safe potable water, reliable heat and electricity, and environmentally benign sewage disposal -- is one of the main challenges to construction in locations without reliable grid based infrastructure. It has been common practice for developers of off-grid buildings (whether off-grid by choice or remote location) to handle the installation of all the required equipment such as diesel generators, septic tanks, and mechanical systems in an uncoordinated way, finding a solution to each requirement independently. The individual components are all physically present, but the equipment has all been selected, and delivered independently -- each item had to be installed individually and tested on site. Although the equipment can be expected to operate and have a reasonable service life, the overall utility system, is a "*make-the-best-of-it*" aggregate of individual units, rather than a planned, purposeful integration of suitable equipment.

2.2 The Combined Mechanical Utilities Container

The "*combined mechanical utilities container*", by contrast, permits important synergies between the various components and in this way, promotes operational efficiency. The physical layout of the components has been researched and planned to minimize interference, create functional synergies and maximize beneficial interactions. All equipment is factory

pre-assembled and the whole system can be factory tested as an integrated utility appliance. The entire structure and equipment remains secure during transport by road, rail, boat or air.
The completely assembled module is shipped and installed in the as-tested format. On site only 7 piping connections, one electrical and one communication connection are required to functionally tie the utilities module to the host building.
The equipment and components are not new in themselves. The distinctiveness lies in the fact that all parts are assembled and secured in one singular utility appliance. The physical proximity and structural integration of the equipment provide an excellent basis to build operational coordination and system synergy. In addition, the system allows the host dwelling to operate independently from any communal service connections, making it invulnerable to problems and outages that might plague a centralized system.

The module builds on proven technologies and combines the following systems into one unit:

- Potable water storage and a 3-barrier disinfection system
- Biological wastewater management and treatment
- Storage and management of recycled non-potable water (used for non-contact applications: toilet flushing, process water, gardening)
- Heat and power generation by means of a custom designed micro co-generation unit (Fuel: diesel, biodiesel, natural gas or propane), power conversion and storage
- Opportunistic use of alternative energy components (micro wind-turbine, solar PV, micro-hydro, solar hot water panels)
- Heat storage and thermal transfer for space and domestic water heating
- Stand alone fire suppression system for utilities module and host dwelling
- Central control function, PLC based data logging and remote dial-in monitoring

Individually, these are all technologies usually found as separate mechanical systems or external utilities in conventional dwellings.

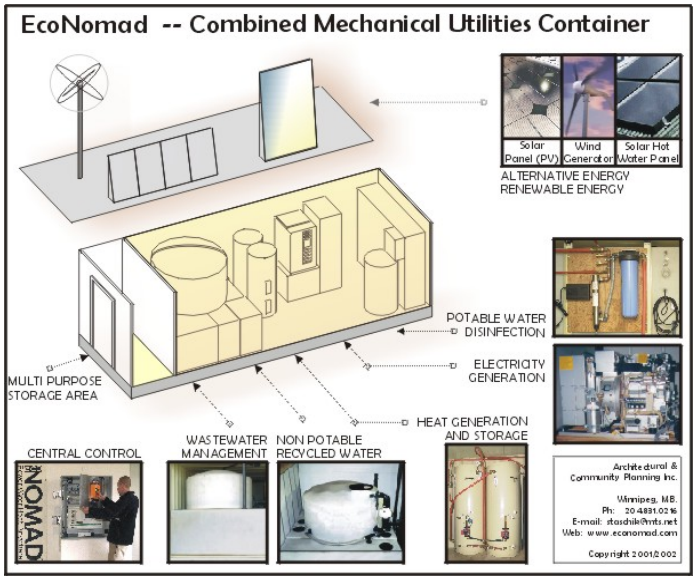

Figure 2: The system diagram shows the main component assemblies. To allow for maximum system flexibility and ongoing opportunities for upgrades the EcoNomad uses a proprietary **"***platform & module***"** approach.

2.3 Equipment and Technical Implementation

The use of existing and proven technologies was a key aspect of the research project. This approach reduces system development cost and engineering time and it ensures availability, serviceability, and reliability of the system components. The concise design of the system and inter-connection of the components allows for factory assembly, commissioning and maintenance of the system by laborers with basic skills and training -- reducing costs and making the technology accessible and understandable to the end-user.

The methodology applied in the research and prototype development was based on the establishment of performance criteria for each subcomponent. Contrary to common engineering practice, none of the components was optimized as an individual stand-alone piece of equipment – rather, an in depth experimental optimization procedure was applied to the entire system. This research methodology led to the development of subcomponent *"system interconnection sequences"*.

2.4 Commissioning of First Prototype in Conjunction with a Custom Build Dwelling

In 1997, Canada Mortgage and Housing Corporation supported the construction of a "Northern Healthy House" in Northern Ontario (400 km east of Winnipeg, Manitoba).
The original budget for the construction of a 3 bedroom, 1152 sqft (107 m^2), super insulated, energy efficient house including the construction of the "*combined mechanical utilities container*" was $ CAD 200,000 and final costs are $ CAD 205,000.
Computer modeling indicated that if a conserving family was to occupy the house, the monthly cost to operate all utilities would be between $ CAD 60 and $ CAD 100. Data logging (in effect since November 2001) shows that the actual operating cost were approximately 20% higher than anticipated, but substantially below conventional systems. In the three coldest months of the year (Dec 2001, Jan and Feb 2002) the average monthly cost of diesel fuel was less than $ CAD 140 - this being the only input required to produce all electricity, space heating, water heating and all related pumping, system monitoring, and household appliance needs. A comparable single family dwelling in the same community would have a monthly utility cost of $ CAD 400.

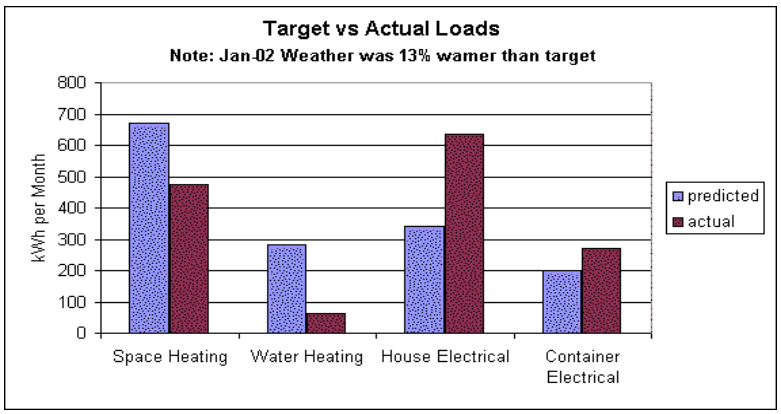

Figure 3: Comparison of Target versus actual loads.

Note: The current occupants of the host dwelling cannot truly be considered energy conservers. They are enjoying an indoor temperature of about +28C as opposed to the Canadian R-2000 design specification of +21C.Consequently the EcoNomad unit works approximately 20% to 25% harder than anticipated.

The continuous operation of the prototype since August 2000 demonstrates that it is possible to provide energy efficient and reliable alternatives to existing central grid-based utility generation and distribution systems. In addition to the low utility costs the occupants benefit from improved health due to the low level of volatile contaminants emitted from building components and from having all mechanical equipment located outside the building envelope.

3. SYNERGISTIC INTERACTION OF INFRASTRUCTURE COMPONENTS

Major benefits in micro-utility development result from the synergy created by optimized interaction of the various mechanical infrastructure components:

- The micro co-generation unit provides electricity as well as space and water heating with a useful fuel conversion factor of 80 % to 90 %, much higher than conventional utilities. The renewable energies - solar and wind - are used in an opportunistic manner when available. The multiple power sources allow for a significant reduction in battery storage capacity, and at the same time encouraging the use of renewable energy systems in areas that are usually regarded as "marginal". By sharing common components, such as the thermal storage, electrical storage, pumps and system controls, synergies are generated that reduce costs, and improve performance.
- The integration of the biological wastewater treatment and management system into the infrastructure module allows for a controlled generation of non-potable reclaimed water. As discussed by Jowett (1999) this water can safely be used for non-contact applications such as toilet flushing, washing machine, process water or lawn watering. In residential applications a reduction of water requirements up to 40% (in commercial applications up to 85%) can be achieved. If desired, further stages can be added to the wastewater management / reclaimed water cycle. At present, several test projects in the Canadian arctic are ongoing and Paloheimo et al (1996) describe that the final product meets aesthetic and approval guidelines for re-use in contact applications (e.g. shower).
- The container houses a reservoir for potable water and a 3-barrier disinfection system. The cascading of potable water uses allows for the use of primary treated water for bath, shower, kitchen and cooking use, less treated water for washing machines, and non-potable, reclaimed water for toilet flushing. Cascading of uses reduces the demand for treated potable water -- directly resulting in water and energy savings.
- At present, we are exploring the following new concept: During the organic breakdown of effluent, the biological wastewater treatment produces a certain amount of methane gas. The internal combustion engine located in the close proximity to the methane producing wastewater management system and a beneficial synergy can be established. Combustion air for the engine is mixed with methane and preliminary opinions indicate, that an 8 % reduction in fuel demand might be possible. At the same time, the methane is burned and thus diverted from being a greenhouse gas contributor.

In addition to the synergy benefits outlined above, the *platform and module* approach to the manufacturing process provides further advantages. Each sub-component is constructed as a stand-alone unit and with the development of new and more environmentally benign technologies, components can be exchanged without effecting the system as a whole.

One good example of this benefit is the emerging fuel-cell technology. The entire spatial concept of the utilities module is ready made to accept a fuel cell, once pricing and consumer demand make this form of combined power and heat production acceptable to the public at large. No change in the overall mechanical interconnection is required. In this way, the novel concept of "*plug and play technology*" for infrastructure and housing is emerging.

All utility systems and utility interface are miniaturized and adapted to service individual dwellings or dwelling clusters in a more energy optimized approach. In addition, the micro-

utility offers economies over centralized grid systems: it eliminates transmission losses, and recaptures heat that would otherwise be lost at source. A widespread system of micro-utilities is also inherently more stable and resistant to breakdowns, ice storms or terrorism that could interrupt central facilities.

3.1 Affordability

The technology has the benefit of increasing energy efficiency, decreasing environmental impact and lowering total infrastructure costs. It makes utilities economically viable particularly in northern, remote and rural locations as well as in developing countries without a well-established utility generation and delivery grid. The micro-utilities module addresses all aspects of conventional infrastructure, with the following improvements:

The economic integration of renewable energy sources, using shared components.

- A reduction of fossil fuel requirements for space heating purposes.
- Conservation of potable water sources and processing.
- Controlled wastewater management and improved effluent quality.

3.2 Resource Conservation and Micro Infrastructure Development

Dunn (2000) describes the "*Eight Hidden Benefits of Micropower*" in his study "Micropower, The Next Electrical Era": as offering the benefits of "*Modularity, Short Lead Time, Fuel Diversity, Load Growth Insurance and Load Matching, Reliability and Resilience, Avoided Plant and Grid Construction and Losses, Local and Community Choice and Control, Avoided Emissions and other Environmental Impacts".*

The EcoNomad combined mechanical utilities container has now successfully demonstrated all the above criteria. The prototype has been in operation since August 2000, providing all utility conveniences to a single-family dwelling located in Northern Canada.

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Policy Instruments for Environmentally Sustainable Buildings

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1. INTRODUCTION

The OECD Sustainable Buildings Project was initiated in 1998 with a financial support from the Japanese Ministry of Land, Infrastructure and Transport. The objective of the project is to provide guidance for the design of government policies to address the environmental impacts of the building sector.

For the last four years, main policy instruments for reduction of CO_2 emissions, minimisation of construction and demolition waste (C&DW) and prevention of indoor air pollution have been theoretically and empirically evaluated according to four criteria; environmental effectiveness, economic efficiency, incentives for innovation and administrative cost. One of the most important steps in the analysis of the characteristics of the instruments is to carefully evaluate how on-going policy instruments are actually workings. Among many findings from the analysis, this paper presents empirical evidence that indicate effectiveness of the policy instruments for the reduction of CO_2 emissions and the waste minimisation, as well as key policy recommendations for OECD countries.

2. POLICY INSTRUMENTS FOR REDUCING CO2 EMISSIONS FROM NEW BUILDINGS

2.1 Energy taxes

Empirical studies on the relationship between energy price and diffusion of energy efficient technologies show a mixed picture. According to an econometric study by Jaffe *et al*, the effect of a 10% increase in energy prices on the diffusion of energy efficient technologies is estimated to be one-third of that of a 10% decrease in capital costs (Jaffe *et al*, 1994). On the other hand, there is some empirical evidence that energy prices may influence the energy efficiency of buildings to some extent. In the US, the relative prices of electricity and natural gas rose respectively by 24% and 69% between 1973 and 1993. It was estimated that without this increase in prices, energy efficiency would have been about 8% lower for room air conditioners, 16% lower for central air conditioners, and about 5% lower for gas water heaters (Newell *et al*, 1998). In addition, regression analysis on nearly one thousand households in the US shows that energy prices affect investment in energy-saving insulation of buildings (Brill *et al*, 1998). In the UK, it was estimated that doubling consumer energy prices would reduce space heat demand by approximately 40% by technical re-optimisation of the building thermal envelope alone. (Lowe *et al*, 1997). As such, views on the potential impact of energy taxes on investment in energy efficiency measures, which are supported by empirical evidence, are mixed, and further studies are necessary to draw any conclusion on the effectiveness of energy taxes in improving the energy efficiency of buildings.

2.2 Subsidy Programmes

There are some empirical studies which show that the reduction of capital cost may have more impact than an increase in energy cost. In addition to the above-mentioned econometric estimates by Jaffe *et al,* Hassett and Metcalf found in their study that tax credits or deductions are many times - about eight times - more effective than ”equivalent” changes in energy prices (Hassett *et al*, 1995). Also, the OECD’s case study on the Commercial Building Initiative Program (CBIP) in Canada suggests that the programme has much potential to influence the decisions of investors. According to a survey of 35 projects in the CBIP, 41% of the respondents answered that the performance of buildings covered by the programme was "much better" than that of the respondents’ other buildings, and 53% replied that performance was "better"

Some studies also indicate that the proportion of free riders is significant. An evaluation of the capital subsidy programme for energy efficient commercial and industrial buildings in Norway indicated that the proportion of free riders is 50-70% (IEA,1997a). According to a survey conducted in 1984 in the US, 88% of the respondents who had claimed tax credits for energy efficiency measures in buildings asserted that they would have made the same expenditures without the tax credits (U.S. Congress Office of Technology Assessment, 1992). They suggest that the reduction of the proportion of free riders is a necessary for implementing subsidy programs effectively.

2.3 Building regulation

Few empirical studies have been undertaken to examine the effectiveness of building regulation in upgrading energy efficiency and reducing energy use in buildings. In the context of the US, econometric estimates of the impacts of building regulations on diffusion of energy conservation measures suggest that building codes made no significant difference in observed building practices in the decade 1979-1988 in the US (Jaffe *et al*, 1994). On the other hand, *ex post* evaluation of the 1995 revisions to building regulations**,** the UK found that the goal of a 30% improvement in energy efficiency was successfully attained. While depending on the context of each country, the enforcement system of building regulation has a long history and has been repeatedly improved, and it can be assumed that energy efficiency standards are generally well enforced in OECD countries. Therefore the main factor which will affect the effectiveness of such regulation may be how high the standards can be set, and in many cases, it may be difficult to set the standards that are strict enough to have a real impact on buildings with relatively high level of energy efficiency.

2.4 Environmental labelling schemes

Concerning the *ex post* evaluation of labelling schemes, the OECD’s case study on the BREEAM found that some 25% of all new office buildings (in terms of total floor area) have been assessed under the BREEAM since its launch in 1991, and that BREEAM-assessed buildings have much higher environmental performances than typical buildings. As indicated in Table 15, the average estimated annual CO_2 emissions from 35 BREEAM-assessed office buildings are less than half of those from typical office buildings in the UK.

The British experience suggests that environmental labelling schemes may have great potential to improve the energy performance of a large number of buildings with limited administrative cost on the government side. However, it is important to note that buildings designed to be highly energy efficient, even in the absence of labelling schemes, are more likely to apply to such schemes to make their good performance more visible. It is thus not clear whether the good performance was achieved because BREEAM provided designers and their clients with incentives to improve building performance, or whether the good

performance would have been achieved even in the absence of the BREEAM, and the buildings applied to the scheme mostly to obtain public recognition for their performance.

Although environmental labelling schemes have been drawing much attention of policy makers and experts, few *ex post* studies on their effectiveness have been undertaken. There appears to be no clear empirical evidence that labelling schemes can significantly improve the energy performance of buildings.[1] In light of the great potential of this instrument, further *ex post* studies need to be conducted. Furthermore, the results from such studies should be reflected in the design and implementation of environmental labelling schemes in the future.

3. POLICY INSTRUMENTS FOR REDUCING CO2 EMISSIONS FROM EXISTING BUILDINGS

3.1 Subsidy programs targeting low-income households

The OECD's case study on the New Home Energy Efficiency Scheme (New HEES) found that the programme has contributed substantially to improving energy efficiency. In the first 9 months of implementation, the New HEES improved 89,000 dwellings. This may be partly because the entire cost for the upgrades is subsidised. It is estimated that the New HEES packages will reduce the cost of fuel used by households by between £300-600 per annum. Theoretically, the upgrades should be very cost-effective. The average amount of grant per household is estimated at some £600, with the estimated pay back period being 1-2 years. It is important to note that the rebound effect has been identified. It is estimated that 77% of the energy saving potential achieved under the Home Energy Efficiency Schemes was used to make homes warmer. (Bell *et al*, 1996). This suggests that this type of capital subsidy programme in the short run may not produce great energy savings, though the programme could be an effective measure to reduce CO_2 emissions in the long run if sufficient financial resources are provided.

3.2 Building regulation

Although there are not many empirical studies that evaluate the effectiveness of the building regulation for existing buildings, some reported successful cases demonstrate that Residential Energy Conservation Ordinances in the US could be a very effective instrument to improve the energy efficiency of existing buildings. In San Francisco, RECOs have resulted in the weatherisation of more than 160,000 homes and reduced average household energy consumption by more than 15%, saving the city a total of US$6 million. It is also estimated that out of 90,000 homes that were inspected by private energy auditors in the State of Wisconsin, between a third and a half of the buildings that were built prior to 1978 - and were covered by the ordinance - had been weatherised as a result of the ordinance. (Suozzo *et al* , 1997)

3.3 Energy audit programmes

Empirical evidence suggests that energy audit programmes are very effective for promoting energy efficiency investment. Some evaluations of energy audit programmes in the US show that energy audits have influenced decision-making of approximately 67-80% of the households participating in the programmes. An evaluation in one state shows that RCS (Residential Conservation Services) participants realised 32% of the identified potential savings for space heating compared to 12% for non-participants (IEA,1998). The Danish case study also found some empirical evidence that energy audit programmes can encourage

1. This argument is applicable to other environmental attributes that environmental labelling schemes of buildings cover.

energy efficiency upgrades. In order to evaluate the effectiveness of such schemes, telephone surveys of owners who had purchased buildings in recent years were conducted in 2000. Three hundred owners of both small and large buildings for which energy labelling reports had been issued - as well as another 300 owners of buildings without reports - were asked questions about energy efficiency upgrades. 45% of owners of assessed small buildings conducted heating-related upgrades within one year, while 38% of owners of non-assessed buildings did so. (Danish Energy Agency, 2001a) For large buildings, this difference increases. While heating-related upgrades were conducted in 47% of assessed large buildings, this was done in only 22% of non-assessed large buildings. (Danish Energy Agency, 2001b)

4. POLICY INSTRUMENTS FOR MINIMISATION OF C&DW

4.1 Landfill tax

OECD's case studies in Denmark, the Netherlands and the UK clearly demonstrate that the tax is a very effective instrument for the reduction of final disposal if the tax rate is set at an appropriate level. In the case of the Danish landfill tax, an analysis of the relationship between the tax rates and recycling rates of C&DW clearly indicates that the tax has contributed greatly to the increase in the recycling rate. Although the tax did not appear to be effective for the first three years when the rate was as low as 5 Euros per tonne, the recycling rate began to increase rapidly after the rate was more than tripled in 1990, and the recycling rate has kept on rising with increases in the tax rate. An analytical study on the effectiveness of the policy instruments also found that municipalities, which are directly responsible for the management of C&DW, believed that the successful increase of the recycling rate could be attributed mostly to the tax. One reason may be that the recycling rate had already reached a very high level before other policy instruments, such as a ban on landfill, was introduced in the late 1990s.

In the Netherlands, the landfill tariff, including a tax for non-combustible wastes such as C&DW, was set at around 12 Euros/tonne when it was introduced in 1996. After repeated minor increases, the rate was greatly increased in 2000 to 70 Euros/tonne. It is widely believed that the landfill tax is the instrument that has contributed the most to the high recycling rate of C&DW in the Netherlands. The yearly trend of the recycling rate highlights the large impact the landfill tax has had on recycling. The recycling rate exceeded 90% in 1995 when the landfill tax was announced and the other instruments had not yet been implemented.

It is also important to note that even after exemptions from the landfill ban have been granted for several kinds of C&DW at the beginning of 2000,[2] the recycling rate reached its highest level in 2000 with the increase of the landfill tax rate. This appears to be additional evidence that the tax has been more effective in promoting recycling than regulation (*i.e.* the landfill ban). It is important to note that while landfill taxes have successfully reduced the final disposal of C&DW in these countries, they have not greatly contributed to promoting the use of recycled materials in building construction.

2. Because there was a large shortage of capacity at incineration sites.

4.2 A ban on landfill

OECD's case studies in Denmark and the Netherlands could not find any empirical evidence to suggest that landfill regulation contributes considerably to the high recycling rate in these countries. In fact, the ban was introduced after the recycling rate had already reached a high level due to a landfill tax that was introduced in both countries. In this case, it is difficult to isolate the effect of the ban from that of the tax. In the case of the Netherlands, it was reported that the ban on landfill has not been enforced very effectively due to some cases of fraud regarding the above-mentioned certification process. In addition, exemptions from the landfill ban have been granted for several kinds of C&DW since the beginning of 2000, because of a shortage of capacity at incineration sites.

4.3 Mandatory separation

Case studies in Denmark and the Netherlands could not find any empirical evidence to support that regulation on mandatory separation has had a large impact on the recycling rate. On the other hand, some evidence suggests that enforcing this regulation is difficult. For instance, the Dutch study found that the local regulation has not been enforced very effectively.

4.4 Mandatory reporting

Case studies found that mandatory reporting could work effectively for preventing illegal dumping. In Denmark, for example, all municipalities have established databases into which they enter the information they receive on demolition activities, destination of demolition waste, *etc.* These databases have enabled the municipalities to have tighter control over the treatment of C&DW. This may be one reason why illegal dumping, which increased in some other countries when economic or regulatory instruments were introduced, has not become a big problem in Denmark.[3]

5. CONCLUSIONS

Based on the above mentioned empirical evidence as well as other findings from theoretical studies, the Synthesis Report of the OECD project include the following key policy recommendations.[4]

Policy instruments for reducing CO2 emissions from buildings

- Appropriately co-ordinate regulatory instruments and non-regulatory instruments.
- Improve the environmental effectiveness and economic efficiency of building regulation.
- Develop a synergy by combining economic instruments and information tools.
- Place more emphasis on energy efficiency improvement in existing buildings.
- Undertake extensive analysis on the cost-effectiveness of energy efficiency measures.

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3. It should be noted that many other factors, such as geographical conditions and cultural background, may affect the incidence of illegal dumping.

4. For details and other policy recommendations, please have a look at the OECD's website (http://www.oecd.org/EN/home/0,,EN-home-495-nodirectorate-no-no-no-8-log20310,00.html) The Synthesis Report and other relevant reports will soon be ready for downloading

Policy instruments for minimising C&DW

- Create a synergy for minimising C&DW by co-ordinating policy instruments across the stages of the life-cycle of buildings.
- Reduce the final disposal of C&DW with a combination of economic and regulatory instruments.
- Establish a sustainable material flows within the building sector by promoting the use of recycled building materials in building construction.
- Encourage pro-active response from contractors to reduce construction waste
- Continue to explore possible measures for improving the waste-generation-related performance of buildings. s

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Chemical database
– a tool for the entire Danish construction industry

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1 BACKGROUND

The development and implementation of the Chemical Database (KDB in the following) in the Danish construction industry is a manifestation of the industry's need to comply with occupational health and safety (OHS) legislation.

In august 1999 a large portion of the Danish construction companies joined forces and initiated the development of the KDB.

All work performed by participating companies was on a voluntary basis, i.e. non-compensated work. Under normal circumstances the participants would be competitors, but on this joint endeavour we all worked shoulder to shoulder.

Approximately 6 months later the administrative part of the system had been adapted and implemented. Only a few months later, Skanska Denmark's version of the KDB was in place.

1.1 Legislative requirements

It has for many years been a requirement in Danish legislation that employers must inform employees who work with chemical substances or chemical compounds (chemical products) of the correct use of the substances or products in question.

This means that all professionals who use chemical products must have up-to-date directions for use (see 1.3) of these products. In addition to this employers must have access to up-to-date safety data sheets for the substances or products.

Since the introduction of these legislative requirements different solutions have been tried in order to enable contractors to comply with the requirements.

1.2 Safety Data Sheet (SDS)

The composition and contents of Safety Data Sheets is regulated through EU-legislation and ratified in the respective EU member countries. In short, a SDS has to address 16 issues regarding OHS and environment. Criteria for, when a SDS has to be composed for a given substance or compound can vary from one country to another for example in regardance to threshold values for certain types of substances.

1.3 Directions for use

Based on information from the safety data sheet, experts in BST compose a generic direction for use (paradigm). The direction for use "translates" physical and chemical information from the SDS into a more practical language. The point of this exercise is that the bulk of users of chemical substances and chemical compounds do not have adequate insight in the potential hazards connected with working with the substances or compounds.

1.4 Mandatory BST membership

Many Danish Companies must be member of a BST (**B**edrift **S**undheds **T**jeneste). BST assist member-companies in preventing and solving OHS and environmental problems. Member-companies are also the owners of the respective BSTs.

1.5 Challenges and solutions

The main challenge was in translating requirements and available means into a practically applicable and cost-effective solution, which could be developed and implemented in a wide variety of construction companies within a relatively short period of time.

It was decided that the optimal solution within the parameters was a database with three different ways of accessing data. This way the system would be able to accommodate construction companies of all kinds and sizes and facilitate access to a potentially huge amount of information in an easy, efficient and effective way. It was decided that the BST, who can be considered an impartial party, should perform admissions and revisions of data.

In order to ensure access to valid safety data sheets we chose to attach the safety data sheets to their corresponding direction for use as a file in standard PDF-format. The PDF-format is the suppliers' guarantee that no one intentionally or unintentionally changes the content of the safety data sheets.

1.6 Technical platform

The KDB is offered as package deals taking into account the needs of organisations of different sizes and technological ability:

1. *Web version* – access via Internet Storefront (Web Browser - WB)
2. *Light version* – access via a replica of the main database (Lotus Notes platform - LN)
3. *Full version* – access via Intranet Storefront (WB). The Intranet application is controlled by a replica of the main database (LN)

In Skanska Denmark we chose to implement a full version KDB with a variety of customised features.

2 SKANSKA DENMARK'S CHEMICAL DATABASE

In addition to the functionalities available in the standard version Skanska Denmark has implemented a "filter" which enforces our internal rules and policies related to Quality Assurance, Indoor Climate, OHS- and Environmental Management issues. The filter results in the classification of the chemical products into three categories; "Permitted to use", "Acceptable" and "Not permitted to use". The definition of the filter reflects Skanska Denmark's ambition to be pro-active (setting the height of the bar) instead of reactive ("only" live up to legislative requirements).

2.1 Special needs in Denmark

Skanska AB in Sweden already had a fully functional chemical database before the development of the Danish KDB was initiated. Unfortunately, this did and still does not accommodate Danish occupational health and safety legislation, as:

- Safety Data Sheets must be available in Danish
- You cannot generate direction for use

However, the tremendous work performed by Skanska in Sweden was not useless for Skanska Denmark. In fact, the idea of classifying chemical products in the database has its origin in the studies of the Swedish Chemical Database.

2.2 Basic functionality of KDB

There are a wide variety of functionalities built into the KDB. Not all are accessible to all users. In the following paragraphs the basic functions and special Skanska Denmark features are described.

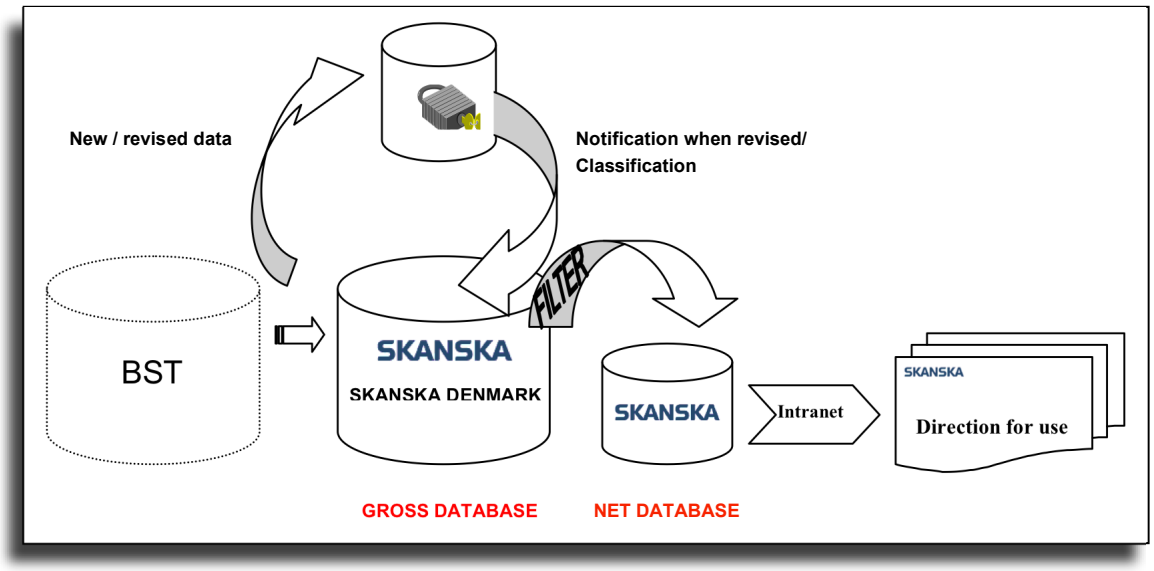

Figure 1: Schematic representation of Skanska Denmark's chemical database

2.2.1 User profiles means differentiated access based on functional needs. After having analysed the organisational and functional needs within Skanska Denmark we chose to define 4 different user profiles which would accommodate the different needs:

- **Non-registered users;** Can search for products and see info-section for the products (only non-interactive features are available)
- **Registered users;** Can search for products, see safety Data Sheets and compose directions for use for products classified as "Permitted to use" and "Acceptable". Allowed to create projects within own department(s)
- **Super-users;** Can search for products, see safety Data Sheets and compose directions for use for products classified as "Permitted to use", "Acceptable" and "Not permitted to use". Allowed to create projects within own division. Can release products classified as "Not permitted to use" for individual projects. Access to monitoring function for generating lists of projects using specific products
- **Administrators;** Total access at all levels. Direct access to comprehensive data in Skanska Denmark's replica of the Lotus Notes database.

Non-registered users share login-name and password. All others are registered as individual users with user profile, personal login-name and password.

2.2.2 Special Skanska feature in directions for use. The standard version of paradigms for directions for use "only" lives up to the legislative requirements. In addition to the standard functionality we have chosen to define an info-section which is presented to the user in combination with the paradigm for direction for use. The purpose of the info-section is to provide all users with basic information about the product:

Product name, CAS-number(s), supplier, supplier's web-site, link to Skanska Denmark's purchase agreement with the supplier, product category, product function, Skanska Denmark's product classification, argumentation for classification, substitution options, code-number reflecting OHS-characteristics, educational requirements for using the product, Hazards symbol (EU-legislation) and comments, where characteristics regarding quality and indoor climate can be inserted.

If the user has access as an administrator or super-user the info-section also contains a field for releasing otherwise not-permitted products to individual departments or projects and a link for generating a list of filled-in directions for use.

2.2.3 Search facilities. There are 4 ways of conducting searches in the KDB:

- Search by typing product name (also wildcard-search)
- Search by typing name of supplier (also wildcard-search)
- Search by typing free-text (search in all data fields – including CAS-numbers)
- Search by browsing through alphabetised product index.

The main purpose of the KDB is to enable us to create directions for use of chemical products and give access to the corresponding safety data sheets. Therefore, the result of a search always ends in a direction for use (or info-section if you are a non-registered user). From here the user can fill in or edit the contents of the form fields and see safety data sheets.

2.2.4 Creating directions for use. Registered users can adapt the generic paradigm so that it reflects the specific conditions for use on the site in question. By filling in 11 form fields in the paradigm the user describes the on-site conditions regarding:

- Place of use (filled in automatically)
- Placement of personal safety equipment
- Contact person for acquiring personal safety equipment
- First aid equipment
- Placement of first aid equipment
- Emergency telephone number
- Placement of fire fighting equipment
- Placement of Emergency preparedness equipment
- Storage of the product (how and where)
- Transport of the product (how)
- Disposal of product (where and how)
- Receiver of disposed product
- Registration of who has composed the direction for use and validation date (filled in automatically)

The direction for use, in its paradigm form, is labelled "UGYLDIG" (void) in large capital red letters. The stamp is only removed when all form fields are filled in and the direction for use is saved.

On an average project one typically has to generate a number of directions for use for a variety of products. Often the same information is inserted into the corresponding form fields for the different products. In order to optimise the process it is possible to generate a series of often-used field values for each form field in the respective projects.

Once the direction for use is filled in and saved you can print it out with or without the info-section. All directions for use should reflect the correct use of a given product under the stated circumstances. Therefore it is not possible to reuse old directions for use from other projects.

2.2.5 Creating and maintaining organisational hierarchy. The system supports the traditional way of defining an organisation. Top level (company) is divided into functional/geographical business units (divisions), which in turn is divided into departments. This hierarchy is defined and maintained by the system administrator.

Users with non-administrative access are allowed to create projects within their own department so that they can compose directions for use within the projects.

2.2.6 Administrative procedures – "behind the scenes". Definition and maintenance of the filter (including classification) is performed by an expert-group. All group-members are EMS-auditors and work professionally with OHS and environmental issues within SD. Two of the three members are educated in the field of chemistry.

The classification is performed as a weighed combination of code-numbers reflecting OHS-characteristics and hazard symbols. Where a product contains substances that are forbidden to use in Skanska the product is immediately classified as "Not permitted to use". The expert-group has defined a set of rules - a matrix defining threshold values for the classification parameters. Skanska Denmark's top management has approved the matrix.

When an existing paradigm is revised by the BST, a flag is raised in Skanska Denmark's KDB. In turn Skanska's administrators can raise a similar flag at the user end so that appropriate actions can be initiated if deemed necessary.

When the BST adds a new paradigm the product is automatically classified as "Not permitted to use". This is a precautionary measure to ensure that potentially hazardous products are not used unintentionally.

Users can request the addition of new products to the KDB by contacting their local Quality Assurance & Environmental Management Co-ordinator who redirects the request to a member of the expert-group. If needed safety datasheets are acquired from the supplier and the request is then forwarded to the BST.

2.2.7 Additional uses. The KDB enables tracking of individual products to the projects in which they were used. In time new knowledge may show that substances formerly deemed more or less harmless in fact have an undesirable effect on the indoor climate. By searching on the name of the substance or CAS-number(s) we are able to track down products containing the substance and consequently also the projects in which the products were used.

One of Skanska Denmark's environmental objectives is to reduce the number of different chemical products in our production and the overall inherent environmental hazardousness of the products we have chosen to use. Skanska Denmark is certified in accordance with the ISO 14001 Environmental Management standard and therefore has to show compliance with formulated objectives. The database can to a very large extend provide Skanska Denmark's top management with crucial statistical material for showing compliance with this environmental objective.

2.3 Implementation

In Skanska Denmark we chose not to perform a large-scale launch of the KDB with formalised education, etc. In stead we chose to introduce the database gradually by seeking out key persons in the organisation. These registered users were then issued with username, password and an easy-to-follow guide. We then established a group of local "experts" as primary support function. This has proven to be sufficient and in many ways more effective than more traditional (formal) methods of introducing new systems.

3 CONCLUSIONS AND PERSPECTIVES

In time we hope to "outsource" the classification work to our colleagues in Skanska Teknik who administrate the Swedish Chemical Database. We hereby hope to obtain a synergy effect, which in turn will contribute to Skanska's world-wide image of being one of, if not the most, environmentally conscious construction companies.

The project parameters have changed somewhat since we began. It is for instance no longer mandatory for a company to be a member of a BST. We have however not seen a decrease in the number of members of our BST – in fact it has doubled to approximately 50,000 members (each member corresponds with one fulltime employee in the member-company). This means that we can now reach twice as many people with the KDB.

In addition to the increase in members we have probed other (related) industries for their interest in gaining access to the KDB. The response has been overwhelmingly positive, which gives us reason to believe that we have developed a powerful concept with enormous potential.

Furthermore, Skanska Denmark is involved in a centre project which aims at developing a generic model for classifying chemical products in a scientifically sound and homogenous way. The scientific anchoring of the project is secured through our partners from Danish Hydraulic Institute, Danish Toxicology Centre, Technical University of Denmark and Roskilde University. In addition to this, six industry partners participate in the centre project.

In close collaboration with one of the other industry partners Skanska Denmark has defined a subproject within the centre project, concerning the development of a model for evaluating potential effects of chemical products on the indoor climate. The model is still in at the drawing board stage.

It is our hope that the development and implementation of the generic model for classifying chemical products will lead to all-round approval and adaptation of our way of classifying products by other organisations. At present time a pilot version of the generic model is being implemented as a simple database and will subsequently be tested by the participating industry partners.

It is our firm belief that the KDB concept is a success and that the Danish construction industry has put a very strong spotlight on the importance of making an effort to reduce the number and toxicity of chemical products in our built environment.

Globalisation and Urban Environmental Risks
The case of São Paulo City

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1. GLOBAL CITIES AND URBAN CONVERGENCE

As some scholars put forward, major cities are undergoing a convergence movement in the age of globalisation, as they grow more and more alike in various aspects, e.g. economic base, spatial organisation and social structure. This applies to major cities in the North as well as in the South. Although the process through which an urban convergence takes place remains quite a puzzle to understand, the similar characteristics among cities points out to the fact that globalisation does have an implication for the urban space. This section deals with this issue and tries to identify a parallel between globalisation and urban environmental risks.

In the celebrated books 'The Global City' and 'Cities in a World Economy', Saskia Sassen (1991; 1994) posits that a group of major cities – e.g. London, New York, Amsterdam, Bangkok, and many others – have become the *main command centres of the global economy* as they headquarter the main financial and corporate institutions of the global economy. In this condition, these cities have become 'sites for the production of: (i) specialised services needed by complex organisations for running a spatially dispersed network of factories, offices and service outlets; and (ii) financial innovations and the making of markets, both central to the internationalisation and expansion of the financial industry' (Sassen, 1991). For this reason, they start to develop similar characteristics in economic terms, which will lead to physical and social consequences.

While Sassen elaborates on the economic and business/financial foundations, Michael A. Cohen's (1996) urban convergence theory goes one step further and sees how the physical environment of major cities is developing alongside globalisation. He agues that major cities are undergoing a process of 'urban convergence', i.e. that they are becoming more alike in their most important aspects, for instance, in terms of growing unemployment, declining infrastructure provision, deteriorating environmental quality and other institutional weaknesses. He posits that urban convergence concerns cities in both developed and developing worlds, as they all are growing alike in view of their challenges for the 21st century, and places all his discussion in a comparative analysis between cities in the North and those in the South. In this context, he presents a common set of critical problems – social, economic, environmental and so forth – which are contaminating urban areas, and concludes that the way cities will react to these problems will largely vary from place to place.

1.1 Infrastructure limitations

Cities in the North as well as in the South have undergone a slow economic growth during the past decade. This was immediately reflected in the slow growth of public investment in infrastructure such as roads, water supply, wastewater treatment, solid waste collection, electricity supply and telecommunications. Even in rich countries such as the USA, a debate was raised about a possible infrastructure crisis following electricity blackouts on the eastern

coast, failed water and wastewater services provision in Chicago and Washington, and problems with road maintenance (potholes, collapsing bridges and so forth) (Cohen, 1996).

In the South, conversely, 170 million urban inhabitants lack clean water supply and poor urban sanitation infrastructure. In Latin America, for instance, a survey conducted in 1994 revealed that only 2 percent of all urban waste was treated before disposal (World Bank, 1994). The problems related to urban transport in major capitals of the South are evident indicators of the deficient infrastructure performance of these cities.

Although the ability of cities in the North to address these infrastructure limitations are different from those of the South, Cohen concludes that both types of cities face an (i) 'apparent lack of financial resources for investment in infrastructure' and (ii) a 'surprisingly weak capacity for infrastructure management'.

1.2 Deteriorating environment

The 'urban environment' was discovered in the North around twenty years ago. Since then, there have been many several attempts to mitigate environmental damage, several of which have been considered very successful. Yet, in most cases, the overall urban environmental quality tends to deteriorate in the North particularly in terms of depletion of natural resources, urban pollution and weakness of environmental governance.

As for the South, a debate concerning the urban environment has only recently begun, where the difficulties encountered by the already precarious environmental infrastructure and governance are exacerbated by the rapid speed at which the cities in the South are growing. Jorge Wilheim, the deputy secretary-general of Habitat II, comments that major cities in the South are facing two severe environmental priorities as they develop from industrial cities into tertiary ones. One of them is the pollution of water resources deriving from untreated domestic wastewater. Needless to say that the growing urban population, overconstruction (overloading infrastructure) and poor housing provision for the lowest-income are the main driving forces for this. The urban deficit in terms of adequate sanitation reaches a very high level in the South, for instance 80-90 percent in cities such as Karachi in Pakistan. The result is disastrous to both the environment and human health.

The second urban environmental priority Wilheim mentions is vehicular atmospheric pollution that is taking over after polluting industries migrate to other areas. Mexico City, for instance, has a population of around 20 million inhabitants and is also home to 4 million cars which produce toxic atmospheric gases 6 times beyond the acceptable standards set by the World Health Organisation (Rogers, 1997). When vehicular pollution is too intense, industrial production is halted and the public is urged to stay indoors. In Bangkok, for instance, over 100000 masks have been handed out to traffic policemen in response to the hospitalisation of one of their members, who had severe lung complications from breathing stifling air.

1.3 The urban space and buildings

The spatial organisation of global cities has also been undergoing a kind of convergence process. The density of the urban tissues, for instance, has been increased as the growing demand for office and residential space leads to the rapid verticalisation and compactness of central districts. The consequent economic and real estate pressures, in their turn, support changes in the local building and urban planning codes, in order to ease the construction permits. As the city grows, not only the land becomes scarce but also natural resources – such as water, air and even light – do also become rare ones.

In the light of this process, we can say that the urban space is facing a severe crisis as major cities are largely growing spontaneously and, in most cases, with insufficient (environmental) planning. Most of them suffer from heat island effect as temperatures within their urban perimeter may reach up to $10^{o}C$ higher than those of adjacent non-urban areas in the same period, severely augmenting the use of air conditioning, therefore the aggregate energy consumption. The rapid reconfiguration of their urban fabrics in order to accommodate a growing number of skyscrapers in most cases does not allow for proper air circulation or for a proper access of buildings to daylighting.

Where buildings are concerned, the increased presence of global institutions (particularly those of the tertiary sector) and the intensified international procurement (that has been eased through globalisation mechanisms) have to some extent also pushed for an apparent homogenisation of architectural expressions and construction techniques. Needless to describe in this paper that this represents an important risk for the urban sustainability. By following international construction models, the resulting buildings are many times totally discontextualised implying higher running costs (in economic and resource use terms) that in turn put an extra load on the local infrastructure system. Most of them demand extremely energy intensive acclimatisation systems, which in aggregate terms represent a significant fraction of the electric energy capacity of the city. Buildings also consume tremendous volumes of water which, when discharged as wastewater, will directly overburden the municipal sewerage systems. Moreover, their many times highly reflective facades further jeopardise the urban microclimate stability. Finally the aggregate building stock consumes land that otherwise could be green land to help alleviate other inner city environmental problems, such as flooding and air pollution. In sum, buildings in major cities pose a severe pressure on the urban environment and infrastructure system.

Governments in the North have already identified the built environment as a major focus of environmental concern, developing several specific programmes for instance to reduce the environmental load that buildings put on cities, therefore their energy and water use, and wastewater emissions. In the South, however, we can say that these issues are only marginally addressed and that, with perhaps few exceptions, there are no concrete programmes oriented in this direction.

2. THE CASE OF SÃO PAULO

2.1 Status as global city and environmental risks

São Paulo is the largest and most affluent city of Brazil, detaining the command centralisation of this country's private capital (about 18% of Brazil's total GDP). The tertiary sector has been ruling the economic activity in this city particularly since 1994 onwards, the year that brought about the inflation stability with the dollarisation of the national currency (Emplasa, 2000). The stability increased the acquisition power of the lower income groups, favouring commercial activities, which, in turn, benefited the service sector. This also happened at a time of increased industrial outsourcing. Nowadays, and in terms of non-residential establishment distribution, the service sector of São Paulo accounts with almost 45% of establishments, the commercial sector with 36%, while the industrial/manufacturing sectors with about 14% (Ibid.).

São Paulo's status as global city was consolidated in the 1990s, as the city developed from an industrial city into an important tertiary and financial capital of the Southern Hemisphere, attracting national and international companies to there locate their headquarters. The changes in its economic profile have also brought about transformations in the urban space. Several new business centres have developed in the city – e.g. the Faria Lima/Vila Olímpia region and complexes such as Berrini/Nações Unidas – where the high investments in the real estate

sector have required parallel public investments in the road and general infrastructure. In the 1990s, 85% of public investments were particularly destined to the expansion of the road network (Emplasa, 2000), leading to the creation of tunnels (e.g. Túnel Airton Senna, under Ibirapuera park) and to the expansion of important avenues, such as for instance Av. Faria Lima and its connection with Marginal do Rio Tietê, the area that concentrates the most valuable office building area of the city.

All of this had contributed to a continuously increasing verticalisation of both residential and tertiary sector buildings[1] and to several environmental and infrastructure constraints. Most of the times, the building typology pursued in São Paulo during the 1990s requires a lot of cooling, posing a severe burden on the local energy infrastructure as well as on the city's microclimate. As for the city's energy infrastructure (which is mostly derived from hydropower stations), the compelled participation in the Brazilian's rationing programme – that started as of June 2001 following a drought period that reduced the reservoirs capacity by 35-40% - has established a mandatory economy of 20% per consuming unit (how this is being achieved we will see in the next sections). In terms of water infrastructure, the increasing load of wastewater and the inability to cope with its treatment led to the contamination of water resources putting at stake the reliability of the whole system and increasing the treatment costs. In São Paulo, water scarcity has become a problem of periodical significance, also requiring rationing programmes.

In terms of environmental quality, the city nowadays presents serious flooding problems due to a decreased level absorptive capacity of the soil following the high level of impermeabilisation in the city (e.g. intense use of asphalt, concrete). The temperature differential between the centre and periphery is of 5°C, proving the existence of heat island effect (Ibid.), a phenomenon that is also related to the excessive use of low albedo (reflecting capacity) surfaces, requiring the use of intensive air conditioning systems. In terms of air quality, an increased presence of ambient dust levels is detected, particularly in the immediate area of construction sites. Moreover, the presence of excessive levels of carbon monoxide, ozone and particulates is extremely high, where vehicles account for 73-94% of most air pollutants (World Bank, 1991). As for noise pollution, about 80% of São Paulo's population lives in areas that are exposed to excess noise, a significant part of this noise derives from construction sites.

2.2 Sustainability policies

São Paulo's water company (SABESP) launched in 1995, in partnership with the IPT (Institute of Technological Research of the University of São Paulo) a programme encouraging the rational use of water in buildings (PURA). The programme involves, among others, the implementation of new norms for a more efficient use of water (including modifications in the building code and standardisation of water saving equipment) as well as of sophisticated monitoring systems in buildings that allow for the control and rapid correction of problems within the water system. The programme has so far developed some pilot-projects following action-plans that took place in some hospitals, public schools, industrial kitchens, commercial and residential buildings. In time, it intends to improve the overall water network of the city by serving more people with the same capacity.

The energy company serving São Paulo City is Eletropaulo, held by AES Corporation after Brazil's energy sector privatisation. During the privatisation process, the National Electric

1 While in 1990, 60% of the total commercial and service constructed area was horizontal, by 1999 it was nearing 53%, the decrease evidencing the verticalisation trend (Secretaria Municipal das Finanças, 1999). If we look at the growth of commercial and service space alone, statistics demonstrate that the vertical development of commercial and service land use area increased by almost 60% during the period of 1990-99, whereas horizontal development increased only by around 25% (Ibid.,1999).

Energy Agency (ANEEL) stipulated that 1% of all energy companies operating in the country net annual income must be devoted to energy conservation projects. As for Eletropaulo, two categories of energy conservation projects are currently fulfilled, one related to R & D and the other to energy saving programmes. As such, the company has been encouraging capacity building courses, efficientisation programmes for commercial clients and for public lighting, distributing energy saving lamps to lower income households and improving the overall technical aspects in the energy supply chain.

As for the planning agencies – and besides the land use code that is there to preserve certain areas (in environmental and cultural terms) – São Paulo does not yet fulfil solid policies towards a general environmental preservation of the urban space. On the contrary, there are certain areas that in principle could not be verticalised, but verticalisation becomes viable through a new law, the Law of Urban Operation (Lei de Operação Urbana), through which developers can pay a certain amount of money for the municipality in order to receive the building permits in areas where verticalisation was supposed to be prohibited. Certain unsuccessful feasibility studies have been made for energy efficient buildings (e.g. Villa Lobos shopping centre, via a co-generation plant), that not only proved economically unviable but that also did not receive incentives from local authorities. The rationale of bioclimatic building design is to a limited extent encouraged by the local building code, but its large-scale implementation is completely hindered due to other market priorities. According to Architect Gian Carlo Gasperini, from Aflalo & Gasperini Ltda. (one of the main architecture firms of the city), bioclimatic towers are economically unfeasible as they never reach an adequate occupation coefficient; a fact that goes against market interests. He further states that the use of brise soleils as to decrease the cooling load of buildings is a hard solution to sell to clients as they require intense maintenance as compared to glazing.

2.3 Corporate buildings in a transnational perspective

We have analysed a sample of four buildings, either owned or rented by multinational corporations to further explore environmental care or risks in globalisation times: ABN AMRO, ING, Andersen and IBM. We selected these companies as they pay a very close attention to the environmental aspects of their premises in their world headquarters (located in Holland and USA) in order to see if they have the same conduct in developing countries, by analysing the case of São Paulo.

How far is environmental care pursued in these companies' buildings in São Paulo? All four companies have a facilities environmental management system, including a waste-recycling scheme. Nevertheless, none of them presents a particular care concerning energy or water efficiency, besides retrofitted fluorescent lamps and water sensor devices in certain lavatories (IBM) or smart lighting and A/C (ING). None of them explores bioclimatic design. Since the start of the energy rationing programme, the premises of ING and Andersen switched on internal generators (fuelled by diesel) so as to cope with the required reduction. The building of ABN AMRO and IBM, which in the past were day and night lit reached the 20% reduction by turning the lights off during the night.

How far do the strategies in São Paulo correspond to the worldwide strategies? The IBM Brazilian headquarters in São Paulo has to achieve an annual reduction of energy and water consumption by 4% and 1% respectively. No extra budget is allocated for this, so the company's staff has to rely on its creativity to achieve the required goal. Despite a comprehensive set of corporate norms, the buildings of IBM worldwide have to follow the most restrictive norms, either the company's or the city's, so this means that if it is not mandatory, no particularities will be pursued. As for ABN AMRO, and despite the thorough sustainable building programmes the company pursues in The Netherlands, sustainable building would only be implemented in Brazil if the local board of directors would come up with the idea. Besides, the amortisation period of these programmes in Brazil would have to

be 2 years (as opposed to 5 years for those in The Netherlands) so as to have the budget approved by the Dutch. The ING Group and Andersen are currently launching a worldwide standardisation process for the premises, which will hopefully be implemented in the coming years.

3. CONCLUSIONS

This paper presented some environmental risks that globalisation brings about to the urban space. In order to conceptualise a relationship between globalisation and the ecological aspects of the urban space, we initially investigated how a group of 'global cities' is being formed and transformed, and how certain environmental problems start to take place. A growing commonality of environmental drawbacks that these cities face point out that globalisation indeed affects cities implying an apparent convergence, homogenisation process of the urban space. Nevertheless, the way cities will react to these drawbacks will vary from place to place. We have in this context analysed the case of São Paulo.

São Paulo's status as global city has triggered a series of morphological transformations – e.g. verticalisation, expansion of business districts, expansion of the city and so forth – leading to several environmental constraints. Some of these constraints are, for instance, an increased level of vehicular pollution, severe flooding problems, heat island effect, energy and water infrastructure limitations and so on. Yet, the sustainability policies pursued in this city are still very insipient.

In terms of building stock, the building typologies currently pursued in this city tend to be discontextualised, requiring a great deal of energy resources to operate. As for their technology, we can say that the scope for the implementation of sustainable, passive buildings, is hindered somehow by market forces. Brise soleils and bioclimatic floor templates are not marketable, energy efficient buildings are at the moment not economically feasible and apparently do not receive support from local authorities. Finally, multinational corporations, which could homogenise a worldwide ecological modernisation process, according to our sample, do not do more than required in environmental care terms for their premises in São Paulo.

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Effective Incentives to Promote Green Building -An Austin, Texas Case Study

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1. INTRODUCTION

The City of Austin Green Building Program has had ten years of experience in using various strategies to promote sustainable building. Four things happened which significantly increased the number of green commercial and multifamily developments. First, Austin's city planning department adopted the concept of "Smart Growth". Then, the Green Building Program worked with Smart Growth staff to include criterion for sustainable practices. The third significant occurrence was City Council's adoption of the SMART Housing program for apartments. Finally, staff from both programs worked together to write clear policy and procedure for participants.

1.1 Description of SMART Growth Concept

Smart Growth is a term that describes the efforts of communities to manage and direct growth in a way that minimizes damage to the environment, reduces "sprawl", and builds livable towns and cities. Smart Growth advocates patterns for newly developing areas that promote a balanced mix of land uses and a transportation system, which accommodates pedestrians, bicycles, transit and automobiles. Smart Growth also seeks to build and enhance our tax base through strategic investments, efficient use of public funds, and regional partnerships.

Incentives are designed to promote three major goals of "Smart Growth" concept, which are:

- Determine How and Where We Live
- Improve Our Quality of Life
- Enhance Our Tax Base

1.2 Austin's Growth Pattern

Austin and the surrounding Central Texas region is experiencing rapid growth in population, employment, and land area affected by development. The City of Austin has grown from a population of 465,000 in 1990 to approximately 630,000 people in 1999. Between 2000 and 2010 Austin is projected to grow by another 170,000 people to a total of 800,000.

The projections for our region are even more dramatic, with regional population estimated to increase from its current 1,096,000 to approximately 1,452,000 by 2010.

This increase in population will inevitably change Austin and central Texas, however, the goal of SMART Growth is to guide and shape this future growth to minimize the negative environmental, economic and social impacts and preserve the best aspects of life in our region.

With the enormous growth in Austin, housing stock is growing, too. In 1999, 347 "new construction permits were issued for multifamily projects. This number represents about 5,000 multifamily units (apartments, condos, or co-housing). It is easy to see how just one multifamily project taking the initiative to "build green" can make a very big environmental impact. Any given multifamily project might mean 4 to 400 (or more) places to live for renters, condo or co-housing owners.

Conservation measures are not only easier to implement while building multiple units, they can benefit multiple occupants, lowering consumption and costs. Similarly, renovations and creative adaptive re-use of any existing buildings can incorporate more energy efficient, sustainable, and healthy systems and materials.

2. LAYING THE GROUNDWORK

The City of Austin has many programs and services for environmental protection and building safety and inspection. These programs have worked independently of each other and in some cases, conflicting with each other. The merging of all these different municipal programs has actually strengthened city services and has encouraged a livable city.

2.1 City Programs

The City of Austin has historically had a strict development review primarily for the purpose of watershed protection. Austin sits on a large aquifer and has carst limestone soils, making the aquifer susceptible to pollution. The municipality also owns its own electric utility, water and wastewater utility, as well as curbside recycling and solid waste disposal services.

The Green Building Program is charged with ongoing sustainable building educational roles for building professionals and the general public. The common goals are to;

- reduce energy and water consumption
- improve air quality
- improve water quality
- preserve vital habitat
- utilize non and least toxic materials with low embodied energy
- incorporate the most locally available and durable materials
- minimize solid waste

The municipal electric utility also provides money and services for energy efficiency upgrades, including; lighting, solar window screens, duct sealing, insulation and high efficiency HVAC. Many Green Building Program projects have benefited from these because the Green Building Program staff cooperates with many *other* city services.

The City's Water Conservation Division provides rebates on water savings upgrades (existing buildings) for irrigation systems, toilets, showerheads, rainwater harvesting systems, and other water conserving equipment. We will provide specific case study examples in the presentation.

Prior to the adoption of Smart Growth and SMART Housing, the environmental goals for green projects, other than energy and water efficiency, had been achieved without the support of financial incentives. These programs now either require or give significant emphasis to overall sustainable building practices.

By combining the components of the various programs including the Green Building Program, SMART Housing, and the Smart Growth program, more projects contribute positively to the environment in Austin.

3.DEVELOPMENT OF POLICY

3.1 Making It All Work Together

Early on the staff administering energy rebates cooperated with Green Building Program staff by cross-referring participating projects. The same was true for water and solid waste rebate programs and incentives. At this point, cooperation among the environmental programs was largely up to the staffs' own initiatives.

After the City Council passed the resolutions affecting Smart Growth and SMART Housing, staff from both departments met with Green Building Program staff to educate each other on their own programs and missions. So that any building project going to any of the departments first would know how to interface with them most efficiently, documents were generated to help guide participants clearly through the process. All departments contributed to and revised these documents and finally held and were to provide them to all new projects.

For both Smart Growth and SMART Housing, three key documents guide the process through the Green Building Program. First, a *"Participation Request"* is sent to Green Building Program staff from the interested project. Depending on what stage the project is in and the interest in sustainable building by the decision makers, more or less technical assistance is provided.

At the appropriate point in a project, a "*Conditional Rating Application"* is submitted to the Green Building Program for review. Included with this should be a Green Building Program *"Rating Tool"* with its proposed score, and all *Construction Documents*. After reviewing, Green Building Program staff either approves, requests more documentation, or denies the application. The appropriate cooperating department (either Smart Growth or SMART Housing is advised of the project's status.

Because the Green Building Program tracks all projects in a computer data base, a special status report for Smart Growth and SMART Housing projects can be generated at any time. The current review status of any project can be viewed between the cooperating departments.

4. PROGRAM COMPONENTS

Following is an overview of the various incentives and tools used by the City of Austin and utilized by numerous green projects.

4.1 Desired Development Zone MAP

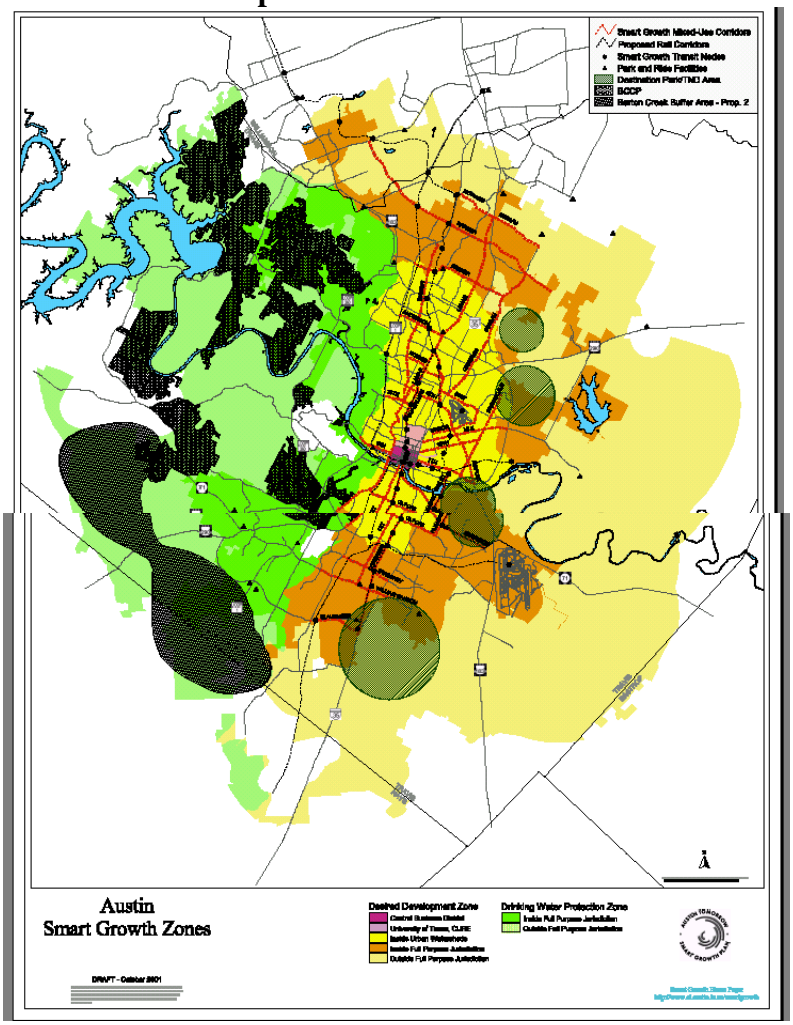

Figure 1

Figure 1 illustrates the Desired Development Zone is shown in orange and yellow on the Smart Growth map. This area encompasses roughly the eastern two-thirds of Austin including the most highly urbanized areas of the city such as downtown and the University of Texas. The Desired Development Zone is where the city wants to direct future growth. However, the DDZ should not be seen as uniformly suitable for development. The Smart Growth Initiative proposes a hierarchy of zones and priority areas within the DDZ. In order of importance, the hierarchy for future growth in the DDZ is as follows:

- Downtown (shown in dark purple);
- Areas with significant opportunities for redevelopment
- Appropriate corridors and transit centers as identified in the Corridor and Light Rail Planning process (potential corridors are shown as dashed red lines, potential transit stations are shown as black dots);
- Infill and redevelopment opportunities within the Urban Core as established in the Neighborhood Planning process;
- Traditional Neighborhood District Zones near Destination Parks (shown as shaded circles along the eastern edge of Austin) .
- Proposed Capital Metropolitan Transportation Authority (CMTA) light rail system (shown as black dashed lines running from northwest to southeast Austin),

The **Drinking Water Protection Zone** (DWPZ) is shown in green on the Smart Growth map. The DWPZ is significant because it includes the following:

- Watersheds that supply a portion of Austin's drinking water;
- Endangered species habitat (shown in cross hatch);
- A portion of the Edwards Aquifer that feeds Barton Springs (shown as shaded hourglass shaped area);
- Steep slopes and shallow soils of the hill country that are not well suited for intensive development.

The Smart Growth Initiative discourages additional development in the Drinking Water Protection Zone due to the environmental constraints found in this area.

4.2 Smart Growth Matrix Incentives

The "Matrix" is a scoring tool used to determine a project's relative worthiness. If a given development significantly advances the City's goals, the project gains financial incentives. These include waivers of substantial development fees. With Smart Growth, the greener the project, the higher the financial incentive. But a project need not be green at all, from a building standpoint, to qualify. It can simply be in the right place. However, green building features contribute significant points on the SMART Growth Matrix.

4.3 Green Building Program and LEED™

A cumulative score on the Smart Growth Matrix determines the monetary incentives for development. The existing Commercial and Multifamily Green Building Programs and the U.S. Green Building Council's program LEED™ or Leadership in Energy and Environmental Design criteria add significant points to this matrix.

4.4 The Smart Growth Zone Specific Incentives

Development Fees are reduced on a sliding scale based on where the project is located.

4.5 SMART Housing Incentives

This initiative is one of the primary reasons that so many apartment complexes are participating with the Green Building Program. Projects that provide affordable units may qualify for development fee waivers and receive expedited review for development permits. SMART Housing requires all projects to comply with a minimum set criteria. Being greener doesn't mean more incentive money to the project, in this case.

4.6 Primary Employer Incentives

This incentive is to encourage large employers back into the preferred area. Primary employer incentives may include fee waivers and expedited development application processing.

5. CONCLUSION

This merging of local incentive programs has been quite successful. In the year 2001, 43,452.28 square meters of commercial space (several of these were mixed use projects that included housing units*)* and 692 multifamily units have been certified as Green and Smart Growth Buildings. 8340 more multifamily units are working toward certification.

5.1 Who Really Benefits?

With the merging of programs, the City of Austin is well on its way to promote a balanced mix of land uses and a transportation system, which accommodates pedestrians, bicycles,

transit and automobiles. Austin has also increased its tax base through this efficient use of public funds.

Because the informed and opinionated citizens of Austin are known for demanding quality of life, more and more projects are adopting sustainable building practices. Smarter and more responsible property owners and developers also know there is clear precedent for a (literally) healthy return on investment when they provide more durable, efficient, and livable buildings. Property owners and managers know that every time an occupant extends a lease, they save money on costs normally associated with turnover. Occupants get lower energy bills, better indoor air quality, and comfort.

5.2 Green Building Program Web Site Resources

More valuable information can be found on the Green Building Program's web site, like fact sheets on paints, cabinets, carpeting, and more. www.austinenergy.com/greenbuilder

Sustainable Sources contains the first publications of Austin's Green Building Program http://www.greenbuilder.com

City of Austin Smart Growth Home Page http://www.ci.austin.tx.us/smartgrowth/default.htm

Green architecture and city transformation: the“sensitive relief” for a cultural approach to the sustainability

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1. INTRODUCTION

The new urban facts of the territory are not easily identifiable neither can be represented through a traditional planimetric relief; however, they have an extraordinary ability of penetration into the different parts of the city. The actual word is kept together by a series of networks, of flux places free from spatial and temporal constraints; the resulting desegregation process of the social community causes the fragmentation and decomposition of the life of the single composing units into a series of episodes, each closed in itself and independent. As a matter of fact, most of the phenomena of the city construction were not realised thanks to the addition of new homogeneous parts, but rather as a result of a multitude of small construction events often without any sort of combinatorial logic. In addition to this type of phenomena, there exist others where the identifiability is entrusted only to the sensitive perception which, however, contain in themselves all potentiality to represent analysis tools and references for planning. In this way, the contemporary city becomes the place of the complexity and of the simultaneity, which determines situations of transivity and transformation.

In such a complex and diversified contemporareity, the sensitive relief, realised through inspections at different levels and with multiple readings, helps to deconstruct, fragment and elementarize the city, allowing new interpretative logic. Nowadays, the elements characterising a sustainable approach to the city development seem not to interact in an integrated manner with the complex articulations of the territory, focusing almost all the attention to the ecological aspect. For the comprehension of these mechanisms and for the construction of a methodology of sensible relief, a necessary introduction is represented by the identification of the new urban elements.

The objective of the sensitive relief is the development of a methodology of complex analysis for the rereading of the territory and the set up of a tool for supporting the different typologies and different scales of the integrated town planning. This is realised through the identification of those elements that constitute the territory, that are fundamental for places recognition, and that are able to cause transformation, also cultural. The method is aimed at producing a sensitive map that provides a complex knowledge of the sites, and at creating proper indicators able to transform the facts contained in the relief into active indices.

2. NEW TERRITORIES AND NEW TECHNOLOGIES

The change of the habits brought to live outside a lot of actions that were performed inside the house, determining an increasing need of new containers. Common daily activities became actions mostly directed out of the traditional orbit and diluted in a wider system: they are beginning to be everywhere and in every moment. We don’t feel contained any more inside our home and we look for other places that could satisfy our demands, places able to receive us. The question consists in moving from a container to another. We spend more and more time inside the shopping malls scattered in our city: big artificial and air-conditioned environments, where we move together with other people making similar actions.

The characteristic of this big containers is that they are able to expand the time devoted to their use and to connect different places through the distracted perception of the world around, relegating the city to a background scene to consume quickly as all the other images offered by the communication culture. We live in the contemporary world travelling through a few landscape sequences, absorbing parts more and more large of our time; and our identity of citizens depends on the frequency and order with which these sequences recur in daily life. To the places of the traditional sociality, the contemporary city substituted places as shopping malls, mega-cinemas, airports, amusement parks. These urban structures were generally built out of the city and they were enriched by functions that simulate urban values suitable to the time of fast traffic. No urban character spreads out these buildings, no fragment of city is drawn on the territory and on the background of the relationships between people. They are not physical spaces where people go to built their social identity; in each of these places people go to buy their undeniable right to anonymity. A multiple ego participating at the same time to several types of person fills these spaces; each of these societies, to which we cannot renounce to belong at once, is rigorously a-topic and able to occupy the space of its localisation, without necessarily having to achieve any identification of it. Moreover, the strong recognizability characterising these no-places gives us the possibility to identify them also without knowing them, because it is not related to a particular type of architecture. These are the new territories of public space, where the bonds of the customs and rules are loose and the most extreme freedom triumphs: in the shopping centre or in the service station there is no public anymore but only the triumph of the individual and autonomous oneself.
On the other hand, however, it is not necessary any more to stay in precise and definite places to exercise communicative, productive and organisational actions. It is the world to change and to move around us: in fact, moving does not mean moving from a point to another of the world, but cross the universe of problems and landscapes of sense. The net, in its actual evolution, is not just a technology for communication, but a real informative and economic ecosystem.
The principles of digital reproducibility of the objects, signs, messages, and also of voice and image represent a prelude to the dissolution of the territory; the nomadism of the information technology era we are living with does not depend on a anthropological transformation but mainly on the continued and quick transformation of the scientific, technical, economic, mental landscapes. The increasing use of Internet, of the cellular phones, and of the new technological tools, caused a wrong idea about the distances and the time. To a standard Internet user it is more obvious to communicate with his e-mail friends living in the other part of the world, than with his desk colleague. New technologies, by creating an artificial nearness and simultaneity between people, things and events, have destroyed the idea of proximity and have produced a constant search of stability and right distance. Consequently, new cultural problems were born: the tolerance, the compatibility and incompatibility between people, their habits, activities, noises, smells.

3. NEW SPACES FOR NEW FAMILIES

The characteristic components of the familiar structures cannot be studied and measured in terms of physical units. Nevertheless they have effect on the course of the human activities of the city, often causing their beginning. The change of the traditional nuclear family has produced a different arrangement of the living spaces. Traditional nuclear family is disappearing from the present urban organisation, being replaced by new forms of cohabitation: young single person, old single person, couple with no child, elderly couple, extended family, enlarged family and mixed family. Inside the extended family, for instance, where different generations live together, or inside the enlarged family, where separate parents cohabit and children born from previous marriages live with the household children,

people with different characteristics live under the same roof. People with different kind of culture, education and job, different relationship with the consumer goods and use of the time. In this way, the house becomes a place with multiple identity and modes of use that change more that once during the day: spaces taken out form public and from private or, more precisely, from the perfect division between public and private. There exist different type of home for different type of household, each corresponding to a different idea of living space, and to a different concept of sites and paths of socialisation, able to influence the formal, functional, and social organisation of the city. The modes of housing express themselves in a language that does not leave tracks that can be immediately codified. In this way the description of the things, of the objects, the behaviour as well as the duration of the rhythms of the life can be understood through the division of the spaces, which become their sensitive expression.

4. NEW PERCEPTIONS FOR NEW CITIES

The elements of perception have a strong relationship with the town and the sites and are often the expression of local, religious and political identity. Although a general flatness of sensitive perceptions inside contemporary cities, it is still possible identify its roots.

Each town owns a typical sound. Going around to record urban voices, it is possible to discover that the background sounds of a lot of metropolis are similar and could bring near Milan to New York or Paris to Tokyo. It is not matter of geometrical nearness, but typological, which does not make them similar neither homogeneous. It just let them intersect in some urban points: commercial centres, transports, infrastructural nodes... Nowadays, however, the sound flatness of the environment makes it difficult to recognise the sounds quality of a site compared to another. One of the reasons is the acoustic pollution, mostly produced by car circulation: noises of transports dominate the acoustic reality of many districts. There are also cultural motivations that, imposing new behaviour and tastes, do influence on the whole sound material of the environment, where the human voices are one of the main components. Cellular phones, for instance, contributed a lot to the acoustic change of the city: the background sound of the town, already full of noises, was enriched by a new range of sounds: the ring of the mobiles, the phone conversations.

The recognizability of the places is strongly entrusted also to visual images: colours, typological characters of the architecture, natural elements. Compared to the modern city, the new landscapes of visual perception are defined by the contemporary presence of different categories of elements, mostly with nonhomogeneous characteristics. In the contemporary city, the elements that mostly are in evidence, with respect to the visual perception, seem to be those of the advertising information. There is no street, no building, no road sign where in some way there are not traces of advertising. And the image of the city and of his elements has changed, becoming the publicity itself a characterising element, which determines at the same time a change of personal behaviour in the paths, shopping habits, etc. Also the monuments, the architecture creations, the buildings inform the pedestrians and the visitors; this information, producing particular aesthetics impressions, contributes to constitute their mental status. The actual tendency is that of embedding more and more of these elements inside the shapes of the buildings and the urban furnishings, often transforming sites in continuous publicity spot.

The sense of smell is the sensorial channel that contains a relationship more direct and almost subconscious with the emotional part of people. A smell can make possible to remember a situation, a place, and a city more than an image. The smell quality of an environment reflects also the quality of life; the smell of food, for instance, is the smell that more characterises a site, also metropolitan. The sense of smell holds a big importance for human psyche and for the human behaviour and influences the city construction and evolution; cultural diversity of

smells becomes an environmental component of the difference between places. The absence of a smell politics and of a concrete action to protect perfumed activities determined a smell flatness of the city with consequences similar to those of the acoustic flatness. The sole areas of the city where it is possible to identify typical smells are the historical sites where traditions last during the time.
Differently from the other senses that have an effective connection to the spatial dimension of the city, the sense of touch brings to a close perception so as to recognise the material qualities of the things. The virtual reality, through machines able to create artificially environmental sensations, is one of the first elements that testify the actual attention to the experience of the touch. The big innovation of these machines relies on the capability to influence this kind of sensations. Also the industrial production of daily objects began to be interested to the touch quality of the products; significant attention is given to the touch message proposed by many electronics objects and from the proliferation of new materials for floors, partition walls, furniture, etc. About the evaluation of the superficial quality of the streets and of the squares of some cities, if, for instance, a floor with stone blocks was attractive in appearance, sound and atmosphere, it was because walking on this floor offered a variety of information and sensations about the historical period, about the physical path. Nowadays, walking on an asphalted street this diversity of information is lost.

5. THE SENSITIVE RELIEF METHOD

Starting from the identification of the new urban facts, the sensitive relief method, which has been elaborated to analyse the urban territory, is aimed at creating a complex map that contains all those elements that are not identifiable in the traditional planimetry. The method is also aimed at creating proper indicators able to transform the facts contained in the map into active indices. At present, the method, the experiments on the field and the indexation process are still work in progress. In the following, a synthesis of the actual status of the research is reported: it represents the proposed methodology developed with the support of the preliminary experiments on the field. The method comprises nine phases, five of which are devoted to the analysis, two are devoted to the check after the third and the fifth phase and the last two are devoted at producing the complex map and the corresponding indicators. A methodological scheme is reported in Table 1.
The *First phase* can be divided in five parts:
- *first part*: selection of the sample cities to analyse. The choice is operated using evaluation criteria based on the dimension, the memory of the citizens, the image that the city represents, the historical interest, etc....
- *second part*: selection of the parts of the city where to focus the study. The choice derives from an analysis of the whole city aimed at identifying all the elements that are important for the construction and transformation of the city;
- *third part*: selection of the most significant days to analyse the cities and the sites in different periods of the year, with respect to the seasonal times and holidays, in order to understand the change of their images and sensitive perception;
- *fourth part*: division of the selected days into time bands: morning, afternoon and evening hours, in order to observe the different uses and rhythms of the sites with respect to the city;
- *fifth part*: choice of the categories and parameters to be used for the abacus of the elements observed in the fifth phase of the method.

The *Second phase* is devoted to an anticipatory analysis aimed at noting all the possible expectations about the selected city and the parts of the city which are to be analysed.
The *Third phase* comprises two parts:

Table 1 The sensitive relief: methodological scheme

Phase	Objectives	Actions
First	Selection of samples	Choice of sample cities
		Choice of parts of the city
		Choice of significant days
		Choice of time bands
		Choice of categories and parameters
Second	Anticipatory analysis	Preliminary observations operated before the analysis on the field
Third	Identification of the elements required for the description of the area	Analysis of traditional planimetry in territorial scale
		Analysis of traditional planimetry in urban scale
Fourth	Check	Check of the choice of parts of the city with the analysis of traditional planimetries in territorial and urban scale
Fifth	Visual and nominal identification of the elements	Sketches of perceptive elements
		Written abacus of urban landscape and perceptive elements
		Photo camera relief
		Video camera relief
Sixth	Check	Check of the different elements observed from different analysis tools
		Check of the different elements observed from the preliminary and effective analysis
Seventh	Elaboration of the information	Reassembling of the identified elements in order to create the graphical symbols system for complex reading of sites
Eighth	Construction of the complex map	Elaboration of complex map using the different components derived in the previous phases
Ninth	Creation of indicators	Classification of indicators through the decodification of graphic symbols

- *first part*: analysis of the traditional planimetry of the state of fact (of the selected sites of the city) in the territorial scale, in order to read the relationships between the site and the whole city;
- *second part*: analysis of the traditional planimetry of the state of fact in the urban scale, in order to read the elements characteristic of that particular area.

The result of this phase is the identification of the components required for the description of the site that can be found only through a traditional planimetrical reading.

The *Fourth phase* is aimed at verifying if the choice of the parts of the city is coherent with the analysis of the traditional planimetries in territorial and urban scale; even though the choice of the cities, sites, days, time bands, categories and parameters represents a fixed point in the method, their number or typology could be changed during the process, if required for a better representation of particular phenomena.

The *Fifth phase* can be divided in four parts:

- *first part*: sketches of the perceptive elements of the site and first attempts of a symbolic representation of such elements;
- *second part*: written description of the observed elements through selected criteria of classification and filing of the data, to create a qualitative and quantitative abacus of the urban landscape and of the perceptive components;
- *third part*: photo relief of the site, from which it is possible to extract useful elements of reading;
- *fourth part*: video relief of the site, from which further reading elements may emerge.

The *Sixth phase* is composed by two checks. The first check is aimed at verifying if the elements observed on the fourth phase are direct results of the adopted analysis tool or are indirect results deducted from logical conclusion; as a matter of fact it is important for the methodology construction to understand the potentiality and the real use of any analysis tool. The second check is devoted to the verification of the difference between the expectations of the anticipatory analysis and the elements observed in the experiments on the field.

The *Seventh phase* is aimed at reassembling the different elements collected in the previous phases, which can also be observed from different points of view. This phase is very

important because it has to produce the components to create the symbols of the complex map.
The *Eighth phase* consists in the construction of the city complex map using all the information of the operated analysis and, in particular, the results of the previous four phases.
The *Ninth* and last phase consists in the classification and creation of the indicators, through the decodification of the graphic symbols that can be derived from the map construction.

6. CONCLUSION

The analysis of the city requires the observation of a wide number of individual and collective subjects operating in different social places, whose behaviour has generated new cultural problems. The aim of this work is that of devising a methodology to improve the understanding of the transformation of the city caused by the change of interpersonal relationships and intergenerational gaps, the new demands connected to this change, the technological development, the globalisation process etc…
The final objective is the comprehension of how the elements representing the ecological and sustainable approach may be compared with a society in a continuous evolution.
A new method is presented aimed at producing a sensitive map that provides a complex knowledge of the sites, and at creating proper indicators able to transform the facts contained in the relief into active indices. Furthermore, this methodology intends to represent a support for the preliminary feasibility studies of the urban planning at the different project scales. Preliminary experiments on the field have been realised; the first results have produced a series of considerations that have conducted to a first upgrade of the method. However a greater number of reliefs are required to construct a first example of complex map.

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How sustainable design concepts can survive a fast track, tight budget, design build process

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1. INTRODUCTION

The general accepted notion is that "Sustainable Design" costs money and that fast track, design build projects cannot afford the time or funds to investigate and implement sustainable design issues. This article outlines how a dedicated design and construction team working on the Burnaby Mountain Secondary School was able to implement sustainable design initiatives at little or no additional cost to the project without negatively affecting the construction process.

The Burnaby Mountain Secondary School is a 15,000 square meter educational facility built to accommodate 1875 students. The school houses spaces for educational and community use, such as gymnasiums, workshops, administration, and a three storey academic teaching area. The school was occupied in the fall of 2000.

This was the first school in British Columbia that was required to be constructed under the new BC Government cost guidelines. The BC goverment established a maximum construction budget of $1040/ sq. Meter, which was considerably lower than the previously accepted cost for the construction of an equivalent secondadary school.

2. DESIGN/ DECISION MAKING PROCESS

The site selected for the school was considered ecologically sensitive and extremely difficult to build on. Challenges included a Ministry of Environment designated salmon spawning creek running down one side of the site, a railway lines running adjacent to the creek and a major four lane highway on the other side of the property. In addition, the school had to be designed and constructed within a 26 month period.

It was decided that the only way to guarantee the project cost and the construction completion date was to adopt a design build / construction management process using an "Intergrated Project Management" approach. The design team worked closely with the owners, the project manager and the contractors throughout the design and construction periods. Some of the driving design issues identified by the project managment team were as follows:

- The school was to be designed for year round use and after hours community usage.
- The school site is very restricted in terms of construction foot print. Requiring the school to be 3 stories high with a number of internal teaching spaces. Some of the internal teaching spaces required mechanical cooling.
- The school is located next to a very busy four lane highway, opening windows/ vents for natural ventilation, during the peak traffic period would be problematic. It was decided very early on in the design process that a mechanical ventilation system with

partial mechanical cooling would be required to maintain acceptable comfort conditions.

- The site also borders on an established residencial area. The residents expressed a desire that they wanted the design of the school to be ecologically sensitive, considering the sites natural features such as established trees/ scrubs, a seasonal pond on the lower end of the site and an adjacent salmon spawning creek.
- The Provincial Government and the school district specified that the design of the new school be enviromentally sensitive (low enviromental impact upon the site and be energy efficient). They also wanted the new school to meet the requirments of the Government of Canada's CBIP (Commercial Building Incentive Program) low energy/ emmissions incentive program and were appropriate, demonstrate state of the art sustainanable technology.
- The Provincial Government guide-lines for school design only permits mechanical cooling in schools for isolated specialty spaces such as computer server rooms etc.
- Indoor air quality was an area of concern identified by the school district.

At an initial meetings with the design and construction team it was determined that a GSHP (ground source heat pump) geothermal heating and cooling system would meet the clients mandate for the following reasons:

- A GSHP heating and cooling system could be designed to heat the school during the winter and cool selected areas of the school during the summer (with no add-on cost for providing summertime cooling). This permits mechanical cooling in areas of the school with no outside walls or where outside windows cannot be opened due to traffic noise or vehicle exhaust. It was also determined that the GSHP system would be permitted to serve the cooling requirments of the school without controvening the Provincial Goverments "no mechanical cooling policy".
- The proposed GSHP system with a central heat recovery chiller allows the transfer of the heat being produced in the internal academic spaces for heating other portions of the school.
- Cooling towers were thought to be contary to the residents and goverments site mandate. The geothermal field was designed so that all of the summer time heat could be rejected into the playing field without the need for a supplimentary cooling tower.
- The proposed GSHP system would be more energy efficicient than a conventional school heating and ventilation system, which would help comply with the owners desire to have an energy efficient, enviromentally concious school.
- The GSHP system could be used for educational purposes, in that the students could be shown how earth energy can be used without degragation of the enviroment. Also the geothermal system could be tied into the site drainage, water conservation/ retention system and biofiltration ponds/ salmon spawning creek. The students could be taught to understand the importance of enviromentally sensetive design and site managment.

As mechanical consultants, we were instructed to produce a number of mechanical design options for costing (a conventional school heating and ventilation system and a GSHP heating and cooling system). The mechanical system options were costed out by the construction team and based upon the costing exercise, the project manager established a budget for the mechanical system (which was close to the cost of a covenventional school heating and ventilation system). The constrution manager challenged the consultants and contractors to meet the set budget with the desired GSHP geothermal system. To meet the

set budget, it was neccessary for the team to think of new ways of designing and constucting the schools GSHP system. Some of the design/ construction cost saving techniques that were successfully used to reduce the cost of the GSHP system were as follows:

- The schools shape, orientation, insulation, glazing, solar shading systems etc were optimized to reduce to schools heating and cooling requirements, so that the schools operating energy and size of the mechanical equipment could be minimized.
- The designers worked side by side with the contractors to ensure that specified mechanical equipment and distribution systems were the most cost effective solutions, not only considering first cost but also maintainace and operating cost.
- Modular design was used where-ever possible to permit effective off site prefabrication.
- Where possible mechanical and electrical systems were exposed, this was done for educational reasons as well as saving in the cost of ceilings. The deletion of the dropped ceilings allowed more natural light into the occupied spaces, reduced the amount of construction material and lowered the cost of the installation and maintainace of the mechanical and electrial systems.
- Where possible, classrooms were stacked vertically to permit fan coil units to be fed from single risers in a clasical "motel mechanical/ electrical service configuration" (minimizing heating water piping, cooling water piping, outside air ductwork, electrical, communication cables etc).
- The layout of the mechanical room was optimised for ease of installation and maintenance.
- The geothermal field was configured to match the playing fields' irrigation and drainage system to minimize the cost of trenching.
- Various design issues were combined into one design solution, such as; the geothermal pipe trenches are also used for the field irrigation pipes, the field drainage system as well as the pathway for drainage water from the roof and the hard surface to the lower biofiltation pond.
- The BMCS (building management control system) was designed to integrate the control of all of the mechanical system components, including the geothermal system as well as the building's lighting, power distribution systems and plumbing water conservation system controls.

Once the cost of the geothermal system was brought in-line with the project budget, it was nessesary for the design team to show that the selected geothermal system would meet the owners and residents enviromental concerns. A DOE2e hourly energy analysis was undertaken to study the energy consumption of the proposed school design. The building envelope, lighting systems, day-lighting, heating, cooling and ventilation systems were all studied in detail to optimize energy-related issues on a life cycle cost basis. The study indicated that the proposed school design (including the GSHP heating and cooling system) would consume approximately 7070 GJ/year as opposed to 9490 GJ/year for a comparable school using a conventional heating and ventilation system. The operating energy cost saving for the Burnaby Mountain Secondary School was calculated to be in the order of $15,000/year, based on 1999 dollars/ fuel cost.

By virtue of the energy efficient design, the school qualified for a $30,000 award/rebate from the Government of Canada's Commercial Building Incentive Program (CBIP) as administered by Natural Resources Canada.

3. BURNABY MOUNTAIN SECONDARY SCHOOL'S HVAC SYSTEM.

The schools' HVAC system uses a GSHP system to heat and cool the building. The GSHP system either extracts heat from the ground or rejects heat into the ground (geothermal field) through 24 km of cross linked polyethene pipe that is buried under the school's playing field.

The geothermal field was carefully designed to ensure that it is easy to maintain. All of the pipe loops from the geothermal trenches are brought back to a valved header in the mechanical room. In case of a failure of one of the pipe loops, the geothermal system will continue to operate. Repairing the failed pipe loop can also be done at a convenient time when the school or the playing field is not in use.

The geothermal pipe trenches were specially designed to ensure that the playing field irrigation and rainwater is channeled away from the salmon spawning stream and into the lower storm retention biofiltration pond. This was achieved by taking advantage of the "clay lense" that existed under most of the playing field. The clay-lined geothermal trenches effectively created waterproof underground channels. The integrated engineered approach to the in-ground field irrigation system, the field drainage system, the geothermal heat reclaim system, and the site water management system, not only saved construction cost but also significantly improved the geothermal system operating efficiency and reduced the water consumption for field irrigation.

The geothermal field distribution system is isolated from the schools distribution system, by means of high efficiency plate heat exchangers to minimized the use of environmentally friendly antifreeze. Reducing the quantity of antifreeze in the system will limit risk of site contamination as well as reducing the operating and maintainence cost of the GSHP system.

A modular, high efficiency heat recovery chiller is used to boost the extracted ground energy to a temperature that can be used to heat the school in winter. The heat recovery chillers have an operating COP (coefficient of performance) in the order of 2.5 to 4.5 (for every kW of energy used by the heat recovery chiller, 2.5 to 4.5 kW of recovered energy is available for heating or cooling the school). The system COP is dependant upon the GSHP system operating temperatures.

Under extreme winter conditions, high efficiency condensing boilers are used to supplement the geothermal heating energy. The GSHP systems' heat recovery chiller and the field are sized to handle approximaty 65% of the schools' peak heating load, which means the heat recovery chiller will be capable of handling the schools heating requirments for most of the year. The condensing boilers can also be used instead of the heat recovery chillers during light load shoulder seasons, if the owner does not want to run the heat recovery chillers because of electrical demand charge penalties or system maintainance.

A 4-pipe fan coil distribution system is used to heat, cool and ventilate the school. The fan coil units are distributed thoughout the school to serve discrete areas (each classroom is served by a dedicated fan coil unit). The fan coil units are generally located outside of the area served so that they can be easily serviced without affecting ongoing activities. Each fan coil unit contains a heating coil, a cooling coils, air filter, noise attenuator, an outside air and recirculation air mixing plenum and a supply air fan.

The indoor air quality is enhanced by the 4 pipe fan coil system by supplying higher than recommended quantities of outside air into the school and resticting recirculation of air from

the area served by the fan coil unit (e.g air will not be recirculated between seperate classrooms). Fiberglass duct lining has been reduced and low emission materials such as duct sealer have been used to reduce fibre shedding and unwanted fumes from entering the ventilation air stream.

A DDC (direct digital control) system is used to monitor and control the installed GSHP system.

The mechanical system is designed so that in the future it can be easily modified to utilize "demand ventilation" control, by adding VAV (variable air volume) devices on the outside air intakes on the fan coil units. This modification would permit the owner to only mechanically ventilate the areas of the school that are occupancy and further increase the operating efficiency of the school.

4. CONCLUSION

The Burnaby Mountain Secondary School project was extremely challenging in that it required the design team not only to come up with complex design solutions to meet the owners specified sustainable design expectations it also required that the design team embrace a new design approach "Integrated Project Management".

From consulting engineers' perspective, the project was professionally rewarding but significantly more time consuming than a conventional school project and ended up being a cost for Stantec. This was mainly due to additional meetings with the design/ construction team members to discuss sustainable design issues, and how the project budget could be met. In Canada, the normal "fee for service" is typically based on the construction value of the work designed. The conventional "fee for service" is insufficient for Integrated Project Management type project, especially when the mandate is to come up with innovative design solutions for construction and energy cost savings. A new fee arrangement should be considered for this type of project that compensates the design team for innovative design solutions that save the client construction and operating capital.

Due to the relatively unique design of the schools' HVAC system, the design team has been required to provide the owner with more than normal post construction support (answering HVAC system operational questions and monitoring the ongoing operation of the installed systems). This additional consulting work should also be recognized and an appropriate fee for post construction services should be made.

The CBIP incentive program assisted in the design process by partially funding the DOE energy simulation and some of the environmental workshops. Without the CBIP incentive, the design build contractor may have been reluctant to fund the required work, which would have put more financial strain on the design team.

I think it can be stated that Burnaby Mountain Secondary School was a successful "sustainable design" project for the following reasons:

- The actual construction cost for the school was $954/sq. meter. This compares to $1040/ sq. meter that is allowed by the BC Government for the construction of a similar sized secondary school. The Ministry of Education budget "unit rates" are based on the Y2000 reduced construction allowances. The reduced construction cost can also be translated into a reduced amount of construction material (less than normal

sheet metal, smaller than normal mechanical and electrical equipmemt, fewer light fittings).

- From inception to occupancy, the school design/construction period was 26 months as compared to 36 months for a similar sized school in BC. This allowed the school district to occupy the building at the beginning of the year 2000 school year, creating significant operational savings to the school district. This also created happier students and teachers, most of who were moving from old style portables. The reduced construction period limited the site distubance time (construction traffic, noise, polution, construction energy and water consumption).
- The owner mandated low CO2 emissions from the new school. The GSHP (ground source heat pump) system and its associated high efficiency heating plant showed a CO2 savings of 126,000 kg per year, as compared to a similar sized school that is designed in accordance with present day "good school design practices".
- The operating energy cost saving for the Burnaby Mountain Secondary School was calculated to be in the order of $15,000/year, based on 1999 fuel cost and the school qualified for a $30,000 award/ rebate from the Government of Canada's Commercial Building Incentive Program (CBIP) as administered by Natural Resources Canada.
- The design considered sustainable design issues such as reduction of operating energy, reducing the schools ongoing water consumption, enviromentally prefered material selection, maintaining natural vegetation and limiting the effect of the school on the existing salmon spawning creek.

In conclusion, it can be stated that sustainable design concepts can be implemented on a fast track, design build, tight budget project, providing the client clearly specifies his sustainable design expectations and the project designers and contractors have the technical ability and the desire to come up with appropiate, cost effective sustainable design solutions.

5. PROJECT TEAM

Award winning mechanical and electrical design firm: Stantec Consulting, Vancouver.
Owner: Burnaby School Dstrict #41
Client: The Learning Consortium (design-build)
Prime consultant: Hotson Bakker Architects, Cornerstone Architects
Other key players: Dominion Construction (construction manager), Fred Welsh (mechanical contractor), Status Electric (electrical contractor), B.C. Hydro (energy simulations), BKG Consulting (project manager).

Guidelines for management of subcontractors in the civil construction services

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1. INTRODUCTION

The subcontracted relationship between contracting and contracted parties is quite frequent and it searches, in a general way, the increase of the entrepreneur flexibility, the increment of the productivity and competitiveness, the costs reduction and the transfer of risks through the delegation of activities to workers specialized in their functions. This process is indistinctly denominated subcontracting in Brazil or outsourcing. But, many times, the process does not revert to competitive advantage for both companies. This way, several difficulties appear in the relationship between constructors and subcontractors, aggravated by the subject of the present workers labor capacitation in both companies.

There are two fundamental moments in this process that need to be discussed: the decision of subcontracting and the management of the subcontractors. For a conscious and objective way of taking of decisions it is necessary the correct understanding of several theoretical and juridical aspects of business administration.

For an efficient administration of the services suppliers and labor in the building sites it is necessary to discuss the process in order to obtain practical orientations. SERRA (2001), in her doctorate's thesis, presents the specific guidelines of administration for the processes of selection, evaluation, contraction formalization and organization of the subcontractors in the building sites of the constructors.

2. GUIDELINES FOR MANAGEMENT OF SUBCONTRACTORS

The success of the undertaking can depend on the luck of finding the ideal subcontractor to a certain service and in how this agreement is consolidated. Many of the subcontract flaws can be due to ill-done choices. Otherwise, there are cases where good subcontractors have celebrated inappropriate contracts and, as a result, they presented a great number of problems and flaws.

The proposed process should happen during the whole development of the decision's process and management of the subcontractors. That is to say, it happens since the beginning of the selective process when it occurs the initial verification of the existence of registered and qualified suppliers for a certain service, passing by the contract elaboration, organization and gauge of the results gotten in building sites and concluding with the evaluation of the quality of the technical attendance service. Figure 1, presented in the sequence, demonstrates the

different phases of the suggested process of administration of subcontractors and its relations with the formation of a subcontractors cadaster.

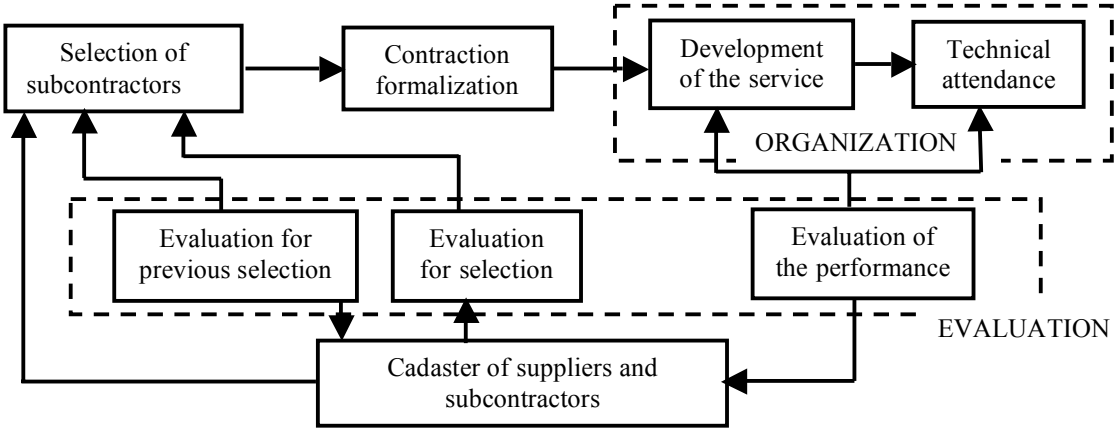

Figure 1 - Proposal of process of management of the subcontractors (SERRA, 2001)

In a general way, the following phases can be considered for the process of management of the subcontractors:

a) selection: systematized process of planning, summons and analysis of the service offers of the subcontractors to define the most indicated one for execution of the project;
b) evaluation: definition of the parameters and approaches to analyze the sent service offers and the subcontractors performance;
c) contraction formalization: definition of rules and clauses to be followed during the elaboration of the contract among the parts;
d) organization: guidelines of administration of the subcontractors during its permanence in the building site and of evaluation of the installment of the service of technical attendance.

To subsidize these analyses, the evaluation systematic will be divided according to the moments when it is made necessary. Thus, the following phases are proposed for the process of subcontractors' evaluation:

a) evaluation for previous selection: it occurs during the selective process and its objective is the analysis of the requested documentation to the qualification and continuity;
b) evaluation for selection: it tries to verify how the price of the service formation occurs and the commercial aspects, technicals and managerial of the offers, in order to facilitate the determination of the most appropriate proposal among the presented ones;
c) evaluation of the performance: it occurs during the development of the service and the installment of technical attendance of the service; it adapts and analyzes the technical, operational and managerial performance of the subcontractors.

The conclusions about the evaluations should be stored in a database that will contain informations about the current and possible suppliers of the contracting company. This cadaster will serve as base for consultation or for supply of data about the subcontractors.

2.1 Guidelines for evaluation and subcontractors selection

The proposition of a methodology of evaluation and selection development is a tool that searches to minimize the relationship problems between the contracting company and the subcontractors. The main phases of the process proposed are identified in Figure 2.

The first step to the analysis be able to determine which is the most appropriate proposal is the definition of the parameters considered priority, that is to say, of those that need to be satisfied by the future contracted. If the same ones are not obtained, the subcontracting process cannot be indicated. Another analysis is about the parameters considered classificatory, that are advisable or that can be negotiable. At each priority level, a weight should be given to the parameter, according to its importance in the strategy. Also relatable to the approaches, its respective weights should be defined too, to facilitate the comparison between the different proposals.

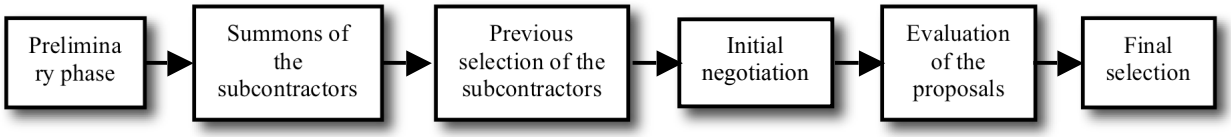

Figure 2 – Main phases of the selective process of subcontractors (Serra, 2001)

The objective of these attributions is the obtaining of a value that would correspond to a final note of the subcontractor proposal that should be understood as an additional information for the process of decision. Through the elaboration of a Map of the Proposals of Subcontractors Evaluation it can be obtained, in a graphic and global form, a visualization of the main informations concerning the service offers and, in this manner, decide more consciously on the ideal subcontractor.

2.2 Guidelines for elaboration of subcontracted contracts

The several professionals' acquaintanceship in the execution of the enterprises of the civil construction is facilitated by the systemization of organizational routines and by the use of tools that integrate these agents. This way, the contract should be considered as a managerial instrument that facilitates the acquaintanceship and the organization of the service in the building site. This benefits both parts, because each one possesses its expectations that need to be previously cleared up (Thomas et al., 1994; Uher, 1991).

With base in the developed studies, the following stages are proposed for a better structuring of the process of formalization of contracts, they are:

a) definition of the types of subcontracted contracts: according to the execution strategy of the service, the main aspects that rule the contracting are discussed;
b) discussion of the contractual clauses: according to the demands and possibilities of the parts, the main contractual clauses are defined.

With regard to the clauses that form the text of the contract, according to Gasparini (1995), they are divided in two parts: essential and accessory. The first ones, under punishment of nullity of the adjustment, they cannot be omitted in the text, while the last ones, they do not affect the business content, they could be omitted. In Table 1 the essential and common clauses for the two strategies and the special clauses of outsourcing can be identified. The creation of that systematic of contracting should reproduce the experiences of the company and works as a intern legislation to be followed whenever there is necessity of agreements of services with other firms.

2.3 Guidelines to the subcontractors organization in the building site

Given the great variety of stages to be managed, Serra; Franco (2001) propose, from a traditional model of administration, an organization form of the subcontractors in the building site. Figure 4 allows a visualization of the proposed project.

Table 1 - Essential clauses of the subcontracted contracts in the civil construction

BASIC CLAUSES (subcontracting and outsourcing)	SPECIAL CLAUSES (only for outsourcing)
1. Description of the object 2. Period of execution and responsibility for delays 3. The formation of the price of the service, supply of materials and rent of equipments 4. Insurance / civil responsibility 5. Conditions of payments, readjust and retention 6. Obligations of the parts 7. Presentation of vouchers and documents 8. Fiscalization form 9. Bonus and premium 10. Safety of the work: PCMAT*, PCMSO** and PPRA*** 11. Inexistence of supply exclusiveness 12. Addition of the contract and accept of the service 13. Fines and contractual rescission	1. Supply of ART**** and approval of projects 2. "Sub-subcontracted" and service packages possibility 3. Guarantee of the service and technical attendance

* PCMAT: Program of Conditions in Environment of Work in the Industry of the Construction.
** PCMSO: Program of Medical Control of Occupational Health.
*** PPRA: Program of Prevention of Environmental Risks.
**** ART: Annotation of Technical Responsibility

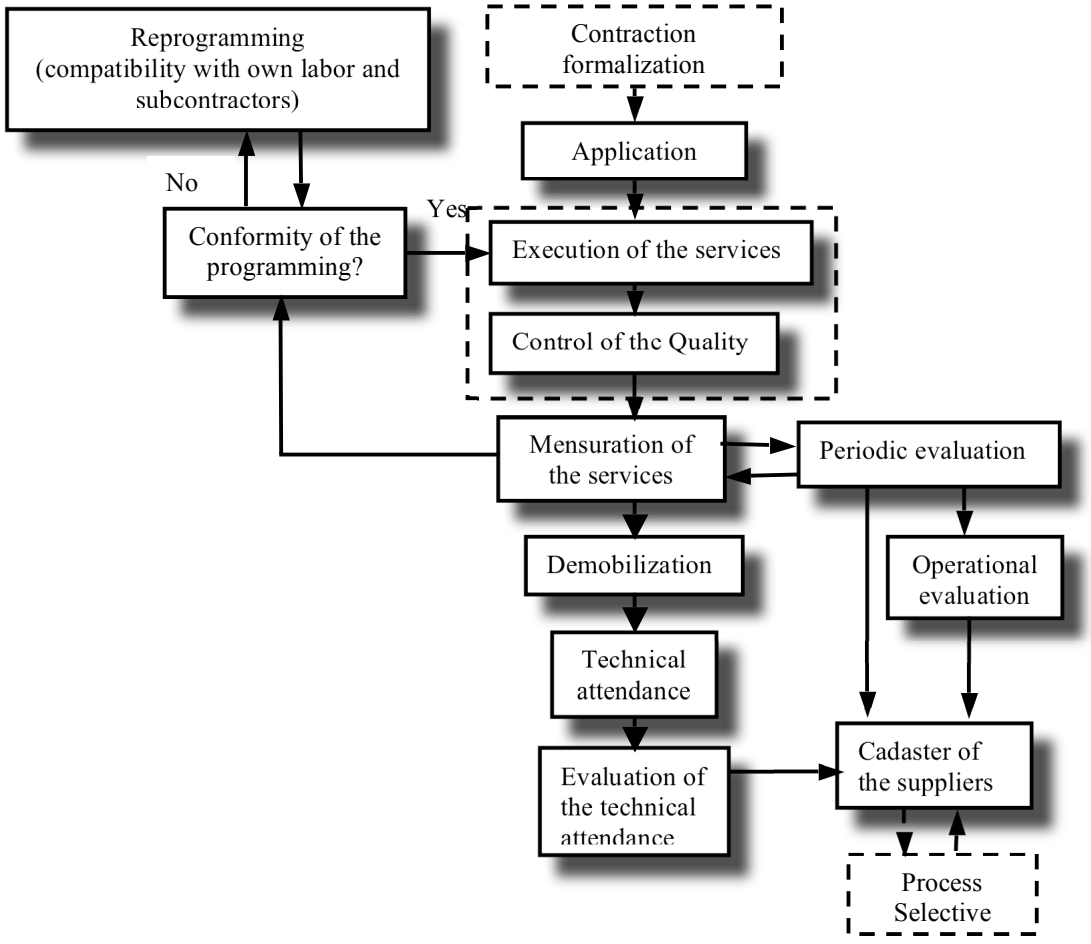

Figure 3 - Subcontractors organization in the building site

The organization should intend the best form of allocation of the resources and of administration of the subcontractors. As the building site is a very dynamic and flexible structure, according to Tamaki (2000), to have organization in it, it will be necessary to guide the project through four basic principle: discipline and understanding of workers, programming of the activities, organization of the work and hierarchization of the work.

Besides that systematization for the organization of the building site, three items are detached to be improved: the worker labor valorization, the compatibility of purposes and managerial styles and the global coordination of the work. To have the best developed of all phases, it is important to establish efficient communication channels among them and the appropriate registration of the decisions, recommendations and done evaluations.

3. CONCLUSION

It becomes necessary, for the survival of the own company that a change happens in the traditional mentality for a new posture organizational and cultural in relation to the organizations that collaborate in the development of its product. The guidelines proposed try to alert the professionals, that did not become aware of the importance of the improvement of the relationship with the subcontractors yet, objectifying, among other things, to acquire more competitive advantage.

We believe that the several-presented recommendations will contribute indeed to the improvement of the administration process of the subcontractors in the subsector building. With the application of the ideas here lifted up, we judge that new ways can be opened for the development and the implantation of innovative technologies, of practices of constructive rationalization, of tools of administration of the quality, that, finally, will allow the such expected treatment of the civil construction as industry.

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Sustainable management in the social housing sector -The Netherlands as case study

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1. INTRODUCTION

The Kyoto Protocol has increased the pressure on governments in various countries to set out strategies for sustainable building to reduce CO_2 emissions. The impact of these national strategies has been studied by Sunikka (2001) in five countries - the Netherlands, France, the United Kingdom, Germany and Finland- all of which have a sustainability strategy for the construction sector. However, Sunikka found out that current policies in all five countries focus solely on new construction, which adds about 1% annually to the total building stock. Also Waals *et al*. (2000) conclude that the real potential for sustainable building and CO2 reduction lies in the management of the existing dwelling stock. The housing associations, as managers of a large segment of the total housing stock, are important actors in the realisation of this potential. This area, however, has been largely ignored in current research and development activities.

The aim of this research, therefore, is to evaluate the state of the art of sustainable management in the social housing sector, using housing associations in the Netherlands as a case study. The Dutch housing sector, 36% of which is social housing (Haffner and Dol, 2000), is faced with reducing its CO_2 emissions by 25 million tonnes between 2000 and 2012. This target can only be achieved through large-scale renovation of the existing housing stock, which for housing associations requires an environmental policy and action plan.

This paper firstly places the Dutch situation in a broader context by examining environmental efforts in the social housing sector in France, the United Kingdom, Germany and Finland. Secondly, we present the outcomes of an empirical analysis, which concentrates on the Dutch situation and provides insight into the environmental policies of housing associations and developments in sustainable housing management since 1993. Finally, we discuss the opportunities for sustainable building and management in the social housing sector.

2. GOVERNMENT POLICIES

The Netherlands, France, the United Kingdom, Germany and Finland were selected for a comparative study, because of their developed, yet different approaches to sustainable building. The study shows that except for Germany that relies on regulation and norms, current government strategies for sustainable building are voluntary, general, and focused on new construction. The social housing sector is mentioned as one target group of the strategy, but governments do not set objectives for it in particular. Consequently, social housing providers consider policies more as general guidelines than action plans, which would require changes in current practice (Sunikka, 2001).

In all five countries analysed, social housing associations themselves have been searching for ways to promote sustainability. In the Netherlands, Aedes, the umbrella organisation for social housing associations, entered into voluntary environmental agreement with government on behalf of its members in 1998. Aedes has also developed strategies to translate the agreement objectives to environmental policy at the housing association level (see Quintis, 1999). However, the national Action Plan for Sustainable Building (MVROM, 1997) does not set specific targets for the social housing sector, which accounts for 75% of the total rental stock and includes 2,3 million homes in the Netherlands (Haffner and Dol, 2000).

France is yet to develop an action program for sustainable building, despite an initiative known as the *Haute Qualité Environnementale* [High Environmental Quality] led by the Association HQE (2000). There is no special HQE legislation or nomenclature; sustainability is a relatively new issue, and general consumer patterns and attitudes are not yet very ecological. Social rental housing accounts for 46% of the total rental stock (Haffner and Dol, 2000), and can, therefore, efficiently promote sustainable building. French social housing providers committed themselves to sustainable development with a common environmental policy in 2000 (Delebarre, 2000). The policy targets are ambitious, but of descriptive nature, and monitoring will be difficult without measurable objectives. This is also the case in the United Kingdom, where the Housing Corporation (2000), which regulates and funds the Registered Social Landlords in England, published its environmental policy in 2000. The social housing sector, which accounts for 60% of the total rental stock in the United Kingdom (Haffner and Dol, 2000), aims in its own actions to support the government policy, which is market-driven and linked to the improvement of competence in the construction industry (DETR, 2000). As the targets are mainly descriptive, only time will tell whether the policy will effect concrete change in current practices.

In Germany, the pursuit of environmental policies and investments in sustainable improvements are not left to the discretion of housing associations depending on their resources. All social housing providers must observe certain ecological standards in order to meet the housing subsidy criteria, which is higher than the building regulations. The volume of social housing in Germany is relatively small, accounting for 15% of the total housing stock (Haffner and Dol, 2000). Financial impact of German public policy will be reflected on the social housing sector soon with the introduction of new thermal regulations, which will also apply to the existing stock, and the renovation expenses anticipated as a result. The Finnish strategy in promoting sustainable construction also relies heavily on the environmental consciousness prevalent in the market. The Ministry of the Environment, (1998) has published its Programme for Ecologically Sustainable Construction. Unlike the other countries studied in this overview, Finland does not have an umbrella organisation for the social housing sector, which accounts for 48% of the total rental stock (Haffner and Dol, 2000). The Housing Fund of Finland (ARA), which grants state loans and approves interest subsidies for social housing, aims to integrate environmental issues in the subsidy criteria in the near future. If this plan is actually implemented, it will make social housing providers very conscious about sustainable building.

Sunikka (2001) concludes that of the five countries analysed, the social housing sector in the Netherlands has the most developed environmental policy. The Netherlands was chosen as a case study for this paper because of its large social housing sector and experience in sustainable building. The description of practical sustainable management in the Dutch social housing associations is based on four surveys. Next, section three describes how the survey data was obtained.

3. METHODOLOGY

The 1998 environmental agreement in the Dutch social housing sector includes a survey program, which was carried out in 1998 and 2000. This paper focuses on the results of the 2000 survey. 700 housing associations were sent a questionnaire addressing qualitative and quantitative aspects of sustainable management, and 190 responded (Atrivé, 2001). Since the size of the associations varied from less than 500 dwellings up to more than 10,000 dwellings, each answer was analysed in relation to the number of dwellings managed by a respondent.

Furthermore, three more surveys were studied for this paper in order to get an overview of developments in sustainable housing management. In 1993, Quist and Van den Broeke (1994) conducted the Sustainability and Housing Maintenance research for the Ministry of Housing, Spatial Planning and Environment. Altogether 253 housing associations and 362 commercial landlords were interviewed for the research to determine the state of the art in sustainable housing management. The 1993 results were used as resource material for this paper to put the 1998 (Atrivé, 1998) and 2000 survey results into time perspective. In 2001, *Stichting Bouwresearch* (SBR) conducted an extensive study into attitudes towards sustainable building among market actors, including housing associations. In total 2,341 questionnaires were analysed, 225 from housing associations. The SBR market research enables an interesting comparison of housing associations answers to the other market actors. References to the SBR market research results are, therefore, made throughout the paper.

5. SUSTAINABLE MANAGEMENT IN THE NETHERLANDS

This section presents the state of art and developments in sustainable housing management in the Netherlands. Figure 1 shows, that one third of the housing associations that responded to the 2000 survey have formulated an environmental policy.

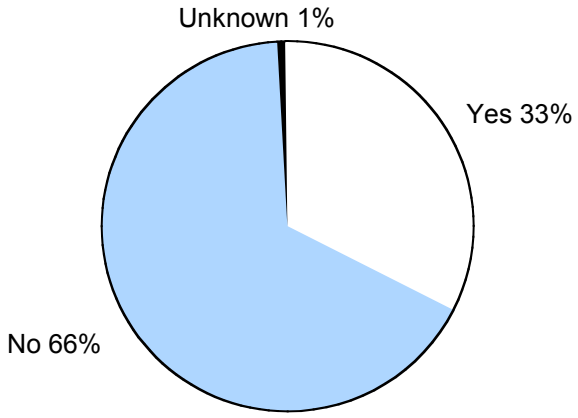

Figure 1 Environmental policies in social housing associations in the Netherlands.

However, housing associations implement environmental measures also without a policy. In 2000, 75% of the social housing associations said they implement environmental measures regularly, and 15% through experiments. 8% of the housing associations do not implement any sustainable measures, while cross-analyses show that these are mostly small associations. Figure 2 shows that the more dwellings housing associations manage, the more environmental policies are formulated. The average size of a housing association with an environmental policy is one third bigger compared to the one without it (Sunikka and Boon, 2002).

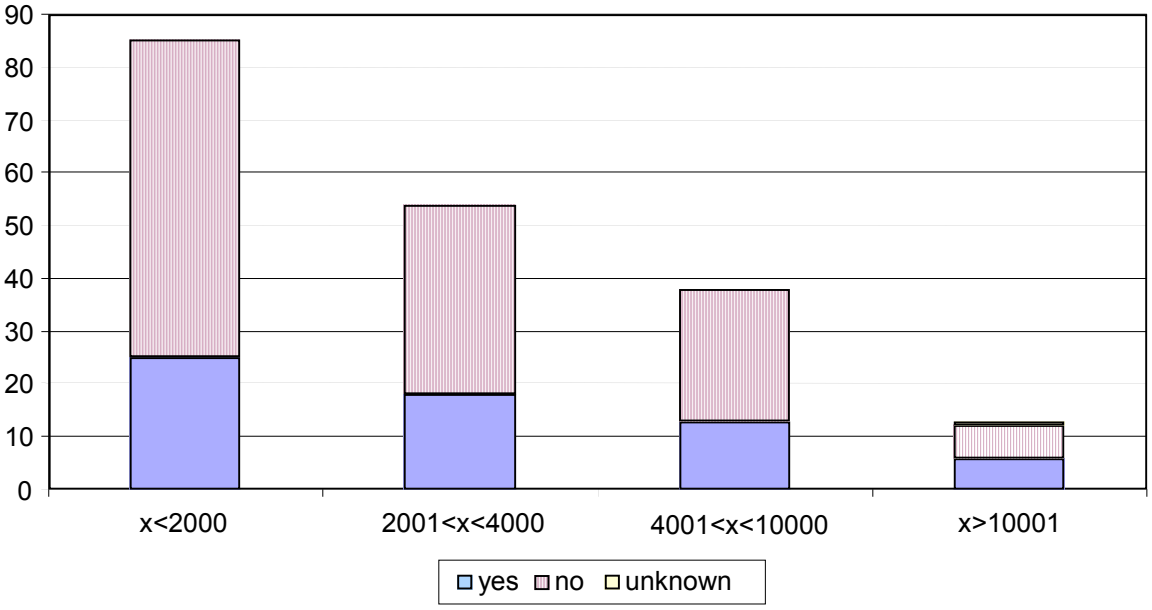

Figure 2 Environmental policies in relation to the number of managed dwellings.

Energy and materials are the most popular measures to be implemented both in new and the existing dwellings. Energy measures are more based on building regulations than investing in experimental measures, although the housing associations like to name energy saving as a priority in their environmental policies. In spite of their well-established position in sustainable building, good indoor quality and water saving measures are seldom implemented in practice. According to the 2000 survey, environmental measures are usually regarded in the early phases in new construction, and in the big interference in the existing stock. Phases were sustainability is less considered are the daily maintenance and a demolition. Sunikka and Boon conclude (2002) that this lack of attention to the existing stock is a serious disadvantage in the future of sustainable building, because a lot of environmental profit can be reached from the existing dwellings.

A comparison of the survey results in 1993, 1998 and 2000 shows, that despite developments in the national strategy, sustainable management in housing associations has not much developed since 1993, and certainly not since 1998. The housing associations spent average 2,964 € per dwelling in sustainable building measures in new construction in 2000, and 71 € per dwelling in the existing stock. Compared to 1998, the investment decreased with 25 %. According to the 2000 survey, costs, capacity and knowledge inside housing associations, and acceptance of tenants, are important barriers to sustainable management. A comparison shows, that since 1993 the attitude has changed cost orientated. In the SBR market research (2001), 43% of the housing associations named subsidies as an important stimulation measure, which is considerably more often than the other market actors do. The real threat to sustainable building, however, is the lack of market demand. The SBR market research shows that Dutch consumers are not very interested in sustainable building. According to the housing associations questioned, 33% of the tenants are interested or very interested in sustainable building, whereas 49% tenants are somewhat interested, and 9% are not interested at all. Furthermore, of those tenants who have interest in sustainable building, only few are willing to invest money in it. The housing associations evaluate that 16% of the tenants are prepared to pay extra for environmental measures, whereas only 6% of the tenants are asking for sustainable building. Consequently, the SBR market research shows that most organisations and companies do not want to profile themselves with sustainable building. 6%

of the housing associations said they always profile with sustainable building, whereas 38% said that they often do, 41% said rarely, and 14% said they never do.

Nevertheless, there are also positive trends. Drawing up voluntary environmental agreements with a third party is major development since 1993. At that time 6 % of the housing associations named sustainable building agreements as a measure to implement environmental policies. In 1998, more than half of the housing associations had made agreements with municipalities, and 40% with energy-companies. According to the SBR market research (2001), 92% of the agreements regard new dwellings, and only 55% renovations. There has also been a change in the use of tools for sustainable housing management, such as the National Packages for Sustainable Building, Duwon and EPA (see Sunikka and Klunder, 2001). Current tools did not yet exist in 1993, whereas in 1998, 66% of the housing associations used the National Package – Housing. The use of tools is still increasing.

6. CONCLUSIONS AND RECOMMENDATIONS

When sustainable building is promoted with voluntary strategy, it is important to survey whether the objectives are implemented. The environmental agreement and its survey program in the Dutch social housing sector aims to give sustainable management a precise and concrete form. As a process the agreement is a good example for social housing in other countries. The research shows, however, that sustainable management at the housing association level is still in the beginning, especially in small associations. When environmental measures are implemented in practice, the ambition level of building regulations is seldom exceeded. Despite few positive developments, sustainable management in Dutch housing associations has hardly developed since 1993. According to the housing associations, costs are the main barrier in adapting sustainable building in daily practice. This conflict between environmental and economic values is recognised in all five countries analysed. Environmental investments are strictly limited by tight budgets as social housing providers face the challenge of coping in a market, and few consumers are willing to make extra investments in sustainable building. Since environmental threats and benefits are not of instant nature for housing associations, efforts towards sustainability are presently more concentrated in separate experiments and demonstration projects than in systematic management. The housing associations also cite lack of proper information as barrier to sustainable management. This indicates a gap between the government policy and its implementation in the social housing sector.

An efficient way is to make housing associations to take environmental action in practice is to increase the use of mandatory measures, such as regulations and taxes. Governments in the five countries analysed can influence the level of new social housing, for example by integrating environmental objectives in housing subsidy criteria. However, due to affordable nature of social housing, and recent decline in the government's influence, social housing associations need to be also motivated with environmental incentives and subsidies.

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Sustainable Urban Development – Requirements for Housing and Buildings

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INTRODUCTION

Sustainable development, as the concept is applied by the World Commission for Environment and Development (the Brundtland Commission, WCED 1987), and later in the UN Environment and Development Conference in Rio de Janeiro, concerns the efforts to ensure that all human beings - in poor as well as in rich countries, today and in future generations - can have their basic needs satisfied in terms of food, water, clothes, shelter, work, energy and hygiene. This must take place without destroying the natural life-support systems of the earth: The atmosphere, oceans and water systems, soil, and biological life. At the same time, the World Commission emphasises economic growth, not only in the poor countries but in the rich countries as well, as a strategic precondition for sustainable development. This is thought to be in line with the requirements of sustainable development, provided that the content of growth is changed by means of extensive, increased eco-efficiency and recycling, and by channelling the growth primarily into activities and industries that are significantly less energy and resource demanding. With the development of the building stock and physical infrastructure as an example, this paper points at the difficulties in combining continuous economic growth in wealthy countries with the requirements of an environmentally sustainable development.

The building stock has continued to grow, independently of the debate on sustainable development. The building projects, particularly within infrastructure, have been larger and more spectacular in the 1980s and 1990s than ever before. Residences, buildings and infrastructure represent long-term investments. They can be recycled only to a limited degree and in practice even less. At the same time, they are just as necessary elements of a society dominated by new "resource efficient" tertiary and quaternary industries as in the industrial society. Besides, they leave substantial ecological traces, especially through the accumulation taking place in the cities. Cities - and their adjacent urban regions - are large spatial concentrations of residences, buildings, and infrastructure. The economic growth of the cities has been synonymous with an increase in the volume of all these elements.

TODAY'S URBAN DEVELOPMENT IS NOT SUSTAINABLE

A report to ECE's 8th conference on urban and regional research in Madrid in 1998 on major trends characterizing human settlements development in Europe, shows that the development is not going in a sustainable direction. Under a set of "mega trends" - characterised by, among

other things, extensive and accelerating globalisation and liberalisation of the economy supported by extensive and accelerating communication networks - a number of changes are taking place in the physical structure of the cities. In part, these changes are linked to the fact that the population in the cities increases as a consequence of a continued urbanisation process in which the population in rural areas decreases. But to an even larger degree the changes in the physical urban structure are caused by a marked increase in the volume per inhabitant of building stock, transport infrastructure, and technically highly affected areas in general. This change in the urban structure leads to increased energy use and increased emissions of greenhouse gases, increased local pollution and noise problems, loss of food-production areas, loss of biological diversity and natural areas, as well as deterioration of landscape qualities and opportunities for outdoor leisure activities (UN/ECE, 1998).
The increase in the per capita consumption is inextricably linked to the economic growth and the prioritisation by the cities and countries of strategies which supposedly support this. At the mega level the globalisation and liberalisation of the economy is a strategy with the very aim of increasing the accumulation of capital and the economic growth. At the region and city level the efforts to develop increased mobility between and within cities express the same ambition, where, in order to compete with adjacent regions and other cities, each region or city strives to promote themselves as attractive as possible for investors, who less and less are tied to certain geographical
localities.

GROWTH OF BUILDING STOCK AND INFRASTRUCTURE

During the period since World War II there has been a steady and significant growth in the floor area per inhabitant in the affluent regions of the world, in dwellings as well as in other types of buildings. In particular, the increase has been strong within the residential sector. Although international data on growth in residential floor space per capita are limited, some data on Scandinavian developments may illustrate trends common to most western European countries in the post-war period. By 1995 each Norwegian occupied on average 49 m^2 of residential floor space, compared with 23 in 1960, 29 in 1970, 36 in 1980 and 45 in 1990 (Hansen, 1995; Bartlett, 1993). In Sweden, residential floor space per capita was 43 m^2 in 1993, compared with 27 m^2 in 1969 and 37 m^2 in 1982 (Swedish Housing Directorate, verbal communication). In Denmark, the floor area per capita in dwellings increased from 23 m^2 in 1960 to 51 m^2 in 1996 (Røpke, 2000:68).
Some of this increase is a result of the fact that the number of households and jobs has increased more rapidly than the general population growth. But this can only explain a small proportion of the growth in the building stock. Simultaneous with a decrease in the number of occupants per dwelling (in Norway, for example, from an average of 3.3 persons in 1960 to 2.4 persons in 1990), the average size of dwellings has increased (in Norway from 76 m^2 to 108 m^2 during the period from 1960 to 1990).
Except from agriculture, where the building stock (barns of different types etc.) has decreased due to, among others, closing down and mergers of farms, the stock of non-residential buildings has also increased, both in absolute figures and measured as floor area per employee. In Denmark, for example, there was an increase in the total floor area of commercial, industrial and public buildings from 93 million m^2 in 1981, via 117 million m^2 to in 1991 to 131 million m^2 to today (Statistics Denmark, 2000). This has happened in spite of the fact that a steadily increasing proportion of the workforce is employed within the service and office trades, where the number of square meters per employee has traditionally been lower than in manufacturing industries.

Not only has the size of the building stock increased but also the urban area per capita. On average for 11 major European cities, urban area per inhabitant and workplace developed from 88 m^2 in 1960 to 122 m^2 in 1990, implying a 38 per cent increase during this 30-year period (Newman & Kenworthy, 1999:110). The spatial expansion has probably been higher in medium-sized and small urban settlements than in the largest cities. In Denmark, the overall amount of built-up areas increased their share of the total land surface of the country from 2.4 per cent in 1965 to 5.3 per cent in 1995 (Danish Ministry of Energy and Environment, 1999). In Spain, the larger cities have used more building land in the period 1965 – 1995 than ever before (UN/ECE, 1998:16). In some countries, like Sweden and Norway, urban sprawl slowed down in the 1980s and nearly came to a halt in the 1990s (Statistics Sweden, 1992; Næss, 1997). In other countries, not the least in Eastern Europe, but also in West Europan countries like Denmark, the spatial expansion of cities is continuing. While the growth of urban area in Danish cities dropped from 49 square kilometers annually in the period 1965-1982 to 30 square kilometers annually during the next 13 years, the conversion of nonurban land into built-up areas is currently increasing in Denmark (Damsgaard & Olesen, 2000).

BUILDINGS, INFRASTRUCTURE, AND DEMATERIALISATION

Concentrated, medium and high density urban developmental patterns require less land for building sites than a low-density and dispersed land use. Hence, densification rather than urban sprawl seems favorable for the protection of natural landscapes, arable land and biodiversity (Fouchier, 1998). In particular, this is the case if the densification can be channeled to brownfield sites, e. g. derelict or under-utilized industrial areas, obsolete harbor areas and parking space incompatible with an aim of reducing car traffic in the urban center (Næss, 1993). Principles of an energy-conscious spatial planning also point rather unambiguously in the direction of relatively dense developmental patterns with a low proportion of detached single-family houses. Concentrated types of housing (apartment buildings and row houses) require less energy for space heating per square meter than detached single-family houses (Asplan Viak, 1995). Dense and concentrated cities are also favorable in terms of energy use for transportation (Næss *et al*, 1996; Newman & Kenworthy, 1999). With a low population density, distances between the various functions and facilities of the city will be long, and trip distances will usually be too long to make walking or biking attractive alternatives. A low density also implies a poor population base for public transport. Within the urban area, location of a high share of new residential development as well as office workplaces in the central and inner areas seems favorable to the goal of reducing auto-dependence in cities. In a number of studies, inner-city residents have been found to travel considerably less by motorized modes than their outer-area counterparts (Næss, 2000). Moreover, the proportion of employees commuting by car is usually considerably higher at workplaces on the urban fringe than in the inner city, at least in cities over a certain size (Næss & Sandberg, 1996).

Thus, concentrated development, re-use of urban areas and more effective utilization of building sites, with apartment buildings and row houses rather than single family houses, seem to be favorable principles in order to limit energy consumption, reduce pollution and protect natural areas and arable land. Principles of land use, location, built form and technical infrastructure matter a lot. The extent of negative environmental impacts may be significantly affected by the choice of solutions.

Still, densification is unlikely to take place without any negative effects at all on within-city vegetation and ecosystems. In addition, the growth in the building stock implies that bigger building volumes need to be heated. A study of a concentrated and a dispersed developmental scenario for a Norwegian municipality (Borre) showed – consistent with the discussion above

– that energy use for transportation as well as in buildings would be higher in the dispersed alternative. However, the total energy use in buildings (residential as well as other) would increase significantly in both alternatives: by 45% in the concentrated alternative and by 62 per cent in the dispersed scenario (Næss, 1997). By means of prioritizing favorable types of buildings in terms of energy, the only thing attained was to *moderate* the strong increase in energy demand caused by the high number of new dwellings and square meters of non-residential floor area presupposed in either alternative.

DEMATERIALISATION AND ECO-EFFICIENCY AS ANSWERS?

This leads us to the question whether it can at all be said to be consistent with a sustainable development to increase the building stock considerably above present levels in wealthy countries like, for instance, the countries of Northern Europe. The construction of buildings is in itself an example of a process in society where it is very hard to imagine that it will be feasible to attain sufficient reductions in the environmental load by "energy efficiency" or "dematerialisation" alone. New buildings imply - regardless of location and design - an increase in the building stock that has to be heated, lit and ventilated, resulting in increased energy use. New buildings also mean a need for building materials and land for building sites. At an aggregate level, the latter contributes to loss of undeveloped land, and frequently increased needs of transportation due to a more sprawling urban structure.

Some of the environmental impacts of the building activity can be reduced somewhat by means of "eco-efficiency" such as solar energy, heat pumps, better insulation materials, and so on. For other types of environmental impacts the prospects through new technical solutions are not so bright. This is especially true in terms of the consumption of land for building sites, with the conversion and encroachments into agricultural soil, natural areas, and valuable landscapes this consumption often implies. Theoretically, it is possible to imagine a "factor 4" or "factor 10" reduction of the land use *per produced unit* by building more densely and higher, as well as placing most of the buildings in areas that are already technically affected, such as traffic areas and derelict industrial estates/brownfields. Building higher and more densely implies a *more efficient* use of the land, whereas the channelling of new buildings for example to derelict or abandoned industrial and dockland areas implies a *reuse* of urban areas, as opposed to taking into use adjacent natural and agricultural land as building sites. However, *the total environmental load of the building stock* will keep on increasing as long as new square meters of floor area are added, regardless of any reduction of the extra load *per newly constructed building.* This is particularly the case for the direct impacts on biological diversity, natural areas, food-production soil, and landscape qualities from converting undeveloped land into building sites.

CONDITIONS FOR SUSTAINABLE URBAN DEVELOPMENT

As shown above, urban development is an area where the economic growth - both the strategies for creating it and the increased consumption it makes possible (and presupposes) - leaves some unmistakable traces in the form of higher consumption of energy and natural resources and a heavier load on nature and environment.

A Norwegian interdisciplinary research project on sustainable urban development (NAMIT) concluded that a sustainable urban development would imply that:

- Most of the construction takes place in the form of densification within existing built-up boundaries
- Few new detached houses will be built. Priority will be given to low blocks of flats and undetached houses

- Restrictions are put on the use of cars in the city, at the same time as public transport is improved
- Most of the concentration is channelled to areas that are already technically affected, so that the green structure can be kept intact as much as possible

(Næss, 1993).

In addition, as argued above, it seems appropriate to add a fifth point:

- The extent of the new construction of buildings and infrastructure should be moderate.

Such an urban development would mean a drastic departure from the current urban development trends. As these trends are closely linked to the economic growth, it is hardly surprising if a change of the urban development in line with the five points above will be met with resistance. There are those who argue that a transition of the urban development so that it no more results in increased consumption of land, energy, and natural resources for building materials will lead to recession and crisis. Implicitly (albeit probably unwillingly!), these arguments also attack the Brundtland Commission's dogma that economic growth without any increased load on natural resources and environment is possible. If such a non-environmentally-harmful growth, understood as a dematerialised growth, were to be possible anywhere, it is likely that this must be in a country with a high degree of economic freedom of action, a high level of prosperity, as well as a high level of knowledge in the population. In this respect, countries like Norway or Denmark might be considered "critical cases" with respect to the thesis that a non-environmentally-harmful economic growth is feasible. So far, however, it looks as if no country - neither in Scandinavia nor elsewhere in the world - wishes to make such an experiment. This is hardly a coincidence.

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Assessing the Economic Consequences of Environmental Decisions

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1. INTRODUCTION

The Green Building Challenge and the conferences on sustainable construction have provided us with a valuable set of tools etc. regarding the environmental performance of buildings. Although environmental issues are becoming important factors for the design of buildings, economic concerns still play a major role in the decision-making process. Thus, bringing economy and environment together seems to be a prerequisite for advancing a sustainable building industry. Life Cycle Costing offers a methodology for assessing the economic consequences of different environmental designs. This study reports on an assessment of three single-family houses in Denmark with distinct environmental profiles.

2. METHOD

2.1 Life cycle costing

Life cycle costs are the sum of capital costs and running costs (costs of management, operation, and maintenance). Capital costs cover construction costs, cost of plot, and the residual value of the property. Taxes, insurance, and administration are included in management costs. Operational costs are composed of costs for operation, cleaning, and energy. The maintenance costs include continuous maintenance, periodic maintenance, and replacements.

The life cycle costs are calculated as follows. First step is to discount the capital costs and the running costs to a specific time (typically the time when the use of the building begins). The second step is to annualise the costs. The annualised costs of two or more alternatives can now be compared.

The calculations of the life cycle costs were carried out with an IT tool developed by Statsbygg, the Norwegian Directorate of Public Construction and Property. The tool is called "Årskostnadsanalyse" (Statsbygg 1998) and was translated into Danish by the Danish Building Development Council (Byggeriets Udviklingsråd 2000).

2.2 Criteria for selecting houses

Three single-family houses were selected for this study. Each house represents distinct environmental profiles: A conventional house built with aerated concrete and bricks; an environmental house built of wood; and an ecological house built of straw bales. In order to ensure comparability, five criteria for selecting houses were used:

- Same type of ownership. All three houses were privately owned.
- Same time of erection. Two houses were erected in 1999 and one house was erected in 1998.

- Same type of layout. All three houses were detached, had one level and nearly same size.
- Same location. This requirement was only partially fulfilled. Two houses were situated in small villages close to Aarhus, whereas the third house was situated in the countryside and considered a farm.
- Same type of household. All three families consisted of two adults and two children.
- Same type of building contract. Regrettably, this requirement was not met. The consequences of this will be discussed below.

2.3 Data collection

To avoid differences of e.g. water fees, all three houses were assumed to be inhabited by the same family and located in the same village (Gl. Rye). Thus, consumption of water, electricity etc. was considered to be the same for all three households. Energy consumption for heating and domestic hot water was however based on the actual consumption and energy source.

Taxes, fees etc. were collected by the author from homepages of the municipality, water company etc. Other data used for the study, such as construction costs, were provided by the owners of the houses and collected by the Danish Centre for Urban Ecology. The quality of data varied. Some data were highly reliable, such as national statistics from the Danish Ministry of Housing and Urban Affairs. Other data were less reliable, such as the construction costs for the straw bale house, which was based more or less on a qualified guess.

2.4 Assumptions

A number of assumptions were necessary in order to perform the calculations:

- The real discount rate was set at 4 %. At the time of calculation, mortgage-credit institutes issued 6 % bonds and the inflation was approx. 2 %.
- The expected lifetime was set to 60 years as default value. This was unfavorable for a conventional house, since brick houses are usually considered to have a long lifetime.
- The standard of electrical work, plumbing, floors etc. was assumed to be the same in all three houses. This was a reasonable assumption judged by drawings and visual inspection.
- The size of the three houses (and outhouses) varied, and consequently the costs were proportionally corrected.
- The price of the plot was not included in the calculations, since all three houses were supposed to be located in the same neighborhood.
- The resale price after 60 years was set to DKK 0 as default value. Again, this was especially unfavorable to a conventional house since conventional houses tend to preserve a high resale price because most buyers of property prefer houses made of bricks.

3. DATA

3.1 Description of houses

The conventional house was situated in a small village called Gl. Rye in Mid-Jutland. The size of the single-family house was 113 m^2 with an outhouse including carport on 42 m^2. The size of the plot was 666 m^2. A developer/contractor built the house in 1999. It was built according to standard practice without any additional environmental measures. The structure was aerated concrete with a facing of yellow bricks and cement roof tiles. Heating energy was supplied from an individual oil boiler. The house was connected to the public sewage system.

The environmental house was situated in a small village called Ry in Mid-Jutland. The size of the single-family house was 115 m^2 with an outhouse including carport on 100 m^2. The size of the plot was 1,439 m^2. The environmental house was built in 1998 by the owner himself

except for electrical work, plumbing etc. The structure was made of wood with a tiled roof. It was built with several additional environmental measures such as:

- 200 mm cellulose insulation material in the walls and 400 mm cellulose insulation material in the ceiling.
- Wood was painted with linseed oil.
- A 9 m^2 solar heating unit and a woodburning stove supplied the house with energy for heating and domestic hot water.
- A greenhouse was added to the house.
- Rainwater was collected and used for washing etc. Thus, the consumption of potable water was reduced to approx. 4 m^3 pr. year.
- The house was not connected to the public sewage system. Instead, greywater was rinsed by reedbed and discharged to a ditch.
- Conventional toilets were replaced by composting toilets.

The ecological house was situated in Saltum in the countryside of North-Jutland. The size of the single-family house was 143 m^2 with an outhouse including carport of 62 m^2. The size of the plot was 11 hectares. The environmental house was built in 1999 by the owner himself, except electrical work, plumbing etc. The structure was a timber and steel construction with straw bales. It was built with some additional environmental measures such as:

- The walls were not insulated, since the straw bales acted as insulation. Straw bales also insulated the ceiling.
- Energy for heating and domestic hot water was supplied by a woodburning stove.
- The house was not connected to the public sewage system. Instead, wastewater was stored in a tank and percolated through mussel shells once or twice a year.

3.2 Annualised costs

Table 1 shows the annualised costs of the three single-family houses.

Table 1 Annualised costs of single-family houses. € 1 = approx. DKK 7.5.

Cost	Conventional (DKK/m^2)	Environmental (DKK/m^2)	Ecological (DKK/m^2)
Capital	503	525	398
Management	197	170	183
Operation	139	79	93
Maintenance	109	233	99
Sum	948	1,006	773

First, the study showed that the capital costs of the conventional house and the environmental house were of the same order of magnitude, whereas the capital costs of the ecological house were considerably lower.

Second, the study showed that the running costs of the conventional house and the environmental house were of the same order of magnitude, whereas the running costs of the ecological house were significantly lower.

Third, the study showed that the life cycle costs of the conventional house and the environmental house were of the same order of magnitude, whereas the life cycle costs of the ecological house were significantly lower.

4. SENSITIVITY ANALYSIS

4.1 Real discount rate

Table 2 shows the result of changing the real discount rate with +/- 1 % for the three single-family houses. The default value is set at 4 %.

Table 2 The significance of the real discount rate.

	Conventional (DKK/m^2)	Environmental (DKK/m^2)	Ecological (DKK/m^2)
3 %	832	913	700
4 %	948	1,006	773
5 %	1,044	1,105	849

The sensitivity analysis showed that changing the real discount rate does not change the relative placing of the three houses. The annualised costs do off course change in absolute terms.

4.2 Lifetime

Table 3 shows the result of changing the lifetime of the three single-family houses. The default value is set at 60 years.

Table 3 The significance of lifetime.

	Conventional (DKK/m^2)	Environmental (DKK/m^2)	Ecological (DKK/m^2)
60 years	948	1,006	755
30 years	not relevant	1,113	891
15 years	not relevant	not relevant	1,266

The sensitivity analysis showed that the life time of the construction is critical. If the life time of ecological houses only reaches 15-30 years, the difference in life cycle costs between the three types of houses will disappear. If the life time of the environmental house only reaches 30 years, the life cycle costs will exceed the life cycle costs of a conventional house.

5. DISCUSSION

5.1 Data quality

Calculations of life cycle costs are no better than the validity of the data used. The validity of data for the conventional house was high. The conventional house was built by a developer/contractor on usual commercial conditions and based on well-known technologies, which gave a fairly good estimate of the capital costs. The running costs was extracted from

public statistics for public supported building of flats and then adjusted to compensate for differences in standard.

The validity of data for the environmental house was fair, but not good. First, most prices of the environmental measures were based on information given by the owner of the house. However, pricing most of the environmental measures was associated with some uncertainty although the owner showed fairly good insight into costs. Second, the structure and facing of the environmental house was made of wood. Although, a number of houses in Denmark is made of wood (however mostly weekend cottages), public key figures on operation and maintenance are not available.

The validity of data for the ecological house was poor. Although the owner built the house himself, he showed remarkable little interest in or concern for the capital costs. Thus, it was possible to obtain only a very rough estimate of costs and man hours spent building the house. Furthermore, the number of straw bale houses is very limited. Thus, statistics are not available. Moreover, most of the straw bale houses in Denmark are rather new. Reliable data on the running costs were therefore not available.

5.2 Price of own work

It was attempted to estimate the construction costs of the straw bale house based on 1,500 man hours (information by the owner) and a wage of 300 DKK/hour. Including the costs of materials etc. the construction costs of the straw bale house were estimated to approx. 5,000 DKK/m^2. The construction costs of the environmental house were approx. 10,100 DKK/m^2. The construction costs of the conventional house were approx. 9,800 DKK/m^2. Apparently, the straw bale house was less expensive to build than the wood house or the brick house.

However, the straw bale house was inexpensive to build because the owner did most of the work. But how do you price the work of the owner? Some would argue that a wage of 300 DKK/hour is far too much for your own work. On the other hand, professional contractors would argue that a wage of 300 DKK/hour is too low to include all labour costs. By sheer coincidence, the owner of the straw bale house is at present building two straw bale houses for clients. He estimates the construction costs at approx. 7,500 DKK/m^2. This estimate was used in the calculations since it is more likely to reflect usual commercial conditions. But the question still stands: What are the real construction costs?

5.3 Taxation

If taxes and fees truly reflected the external costs of different products, the differences in taxes and fees would be a strong incentive to act sustainable. However, this is not necessarily the case.

First, the property tax is a major management cost for all house owners. It is directly proportional with the market value of the house: a higher market value leads to a higher tax. For the time being the market value of straw bale houses is comparatively low, but if house owners start to prefer straw bale houses to brick houses the market value and the tax would increase. Thus the difference in taxation would level out.

Second, the differences in operational costs are not necessarily due to savings on maintenance of the structure but to savings due to additional environmental measures. These additional environmental measures could in principle be applied to any house. As an example, the owner of the wooden house paid for only 4 m^3 of potable water per year. The remaining water

consumption of the household (approx. 126 m^3) was supplied by rainwater. Thus, the owner did not use less water than families in conventional houses. He simply avoided paying for the water – which is a considerable cost for most families. Does this choice of water supply system reflect a sustainable choice or just a creative use of a hole in the tax system?

Third, the preliminary results of an LCA analysis suggested that the straw bale house was unable to conform to the requirements in the Danish Building Regulations which stipulate that heat loss during operation should not exceed 250 MJ/m^2/year. The heat loss from both the environmental house and the conventional house is around 200 MJ/m^2/year, whereas the heat loss from the ecological house is approx. 350 MJ/m^2/year. Thus, the ecological house appears to be the cheapest house to build and run, but it is apparently not the most sustainable (at least with regard to heat loss).

6. CONCLUSION

The study suggests that:

- The capital costs of the conventional house and the environmental house are of the same order of magnitude, whereas the capital costs of the ecological house are somewhat lower.
- The running costs of the conventional house and the environmental house were of the same order of magnitude, whereas the running costs of the ecological house were significantly lower.
- The life cycle costs of the conventional house and the environmental house were of the same order of magnitude, whereas the life cycle costs of the ecological house were significantly lower.

However, the conclusions are sensitive to a number of conditions:

- The validity of data from the conventional house is high, fair for the environmental house and poor for the ecological house.
- Incorporating the resale price in the calculations will especially benefit the conventional house, thus reducing the relative difference between the three houses.
- Changing the real discount rate does not change the relative placing of the three houses, although the absolute numbers change.
- The life time of the construction is critical. If the life time of the ecological house and the environmental house only reaches 15-30 years, then the life cycle costs of the conventional house will be favourable.
- Savings on life cycle costs does not necessarily reflect sustainable choices, but rather that taxation is avoided and/or that the owner carries out much of the work himself.

7. ACKNOWLEDGEMENT

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Developing a method for labeling the indoor environment of a home

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1. INTRODUCTION

We spend about 90 % of our time indoors. The indoor environment can affect our health and productivity (Wargocki, Wyon and Baik et al., 1999). Our home is the most important exposure environment, since we spend 60% of our time there (Pershagen et al., 1993). Health aspects that should be taken into account in designing a good indoor environment include hypersensitivity- and illness-related problems, as well as general discomfort. Allergic diseases have increased sharply in recent decades in countries with a Western lifestyle. One hypothesis to explain this is changes in the indoor environment. The indoor environment can be divided into thermal climate, air quality, noise, lighting and electric and magnetic fields.

The objective of this project is to develop a method for labelling the indoor environment of newly constructed homes, including both apartment buildings and single-family homes. The labelling method will include tools for standard-setting, managing, safeguarding as well as reporting the quality of labelling and taking into account all phases of the construction process. Labelling should consist of a base level that can be supplemented by individual allergy adaptation. The purpose of the base level is to provide a satisfactory indoor environment for normally sensitive people. Individual allergy adaptation only affects the home inside its enclosing walls.

The project, which should be completed by 2005, is divided into five stages:

1. Knowledge acquisition to describe present knowledge of the sub-areas thermal climate, air quality, noise, lighting and electric and magnetic fields.
2. To define the base level for a good indoor environment in the form of identification/quantification of the effects of the above sub-areas. This involves assigning relative values to the factors that we know or believe to be most important for health, and recommended methods of measurement for verification of these values.
3. To develop an evaluation model for building materials in terms of their indoor environmental effects and the health of occupants. Material properties to be evaluated are constituents, emissions, robustness and care and maintenance requirements.
4. To develop a system of aids for the reclamation of indoor environments, such that there is a feedback of experience, with the aim of improving the quality of existing products and of defining occupants' problems.
5. To develop a method or labelling the indoor environment of a home.

The first stage is finished and the above mentioned sub-areas has been examined from three perspectives; 1) What knowledge do we have today? 2) What effects on health can be associated with each sub-area? and finally 3) What standards or recommendations are in force in Sweden, so that health risks are avoided in new homes?

2. METHODS

In all the stages, the method for gathering knowledge about the indoor environment and its influence on health is studies of the literature as well as dialogue with experts in the affected disciplines. I have chosen to limit myself to:

- taking into account the outdoor environment around the home in the form of gaseous and particulate pollutants in outdoor air as well as radon from the soil that enters the home.
- not dealing with technical solutions or systems.
- not dealing with environmental tobacco smoke.
- not dealing with radon in drinking water.

3. THE RESULT OF THE COMPILATION OF THE EXISTING KNOWLEDGE REGARDING THE ASSOCIATION BETWEEN THE INDOOR ENVIRONMENT AND HEALTH

3.1 Allergy and hypersensitivity

Allergic illnesses have increased sharply during the past few decades in Sweden and in most other countries with a Western lifestyle (Formgren, 1998). International studies among children and adults show differences of up to a factor of 30 between countries in the occurrence of allergic problems. We do not know for certain what has caused the explosive increase of asthma and allergy in the Western world in recent decades. Among the hypotheses are hereditary traits, environmental pollution, greater use of antibiotics, changed gastrointestinal bacterial flora and changes in the indoor environment. The hypothesis that has been presented as strongest is our changed lifestyle, which has been demonstrated, given the importance of changed gastrointestinal bacterial flora (Björck, 2001). But today no one can answer whether this is the absolute truth. The increased prevalence of allergies and other hypersensitivity diseases has been linked with changes in the indoor environment (Sundell and Kjellman, 1995). These hypersensitivity illnesses include sick building syndrome (SBS). There is a clear connection with allergy, since people with allergies – especially asthma or eczema – are over-represented among SBS cases. WHO´s definition of a sick building is that the users of such a building have abnormally high frequencies of SBS symptoms. In 1984, a WHO expert group estimated that 10-30% of new or renovated buildings were sick and that 10-30% of the people in these buildings showed SBS symptoms (Formgren, 1998) (Sundell and Kjellman, 1995). In residential structures, symptoms and problems are more common in apartment buildings than in single-family homes (Engvall et al., 2000). Findings indicate that what is measured objectively need not be confirmed subjectively by residents, which is noticeable in the case of thermal comfort, for example. Typical of SBS is that the symptoms appear after a short or long stay in a specific indoor environment (Formgren, 1998). SBS is a matter of symptoms that occur commonly and that may have many causes, which are difficult to distinguish from others. There is thus no operational definition of the syndrome (Thörn, 2001). Research findings concerning the causes of the syndrome are general, unspecific and usually contradictory. Cases should, in practice, be treated more on the basis of practical experience and plausibility than on the basis of strict scientific evidence.

3.2 Thermal climate

We perceive the thermal climate as pleasant when there is equilibrium between the heat we produce in our body and the heat emitted into our surroundings. Thermal climate factors are room air temperature, airflow speed and the temperatures of surrounding surfaces. The perception of thermal climate is also affected by clothing and activity level. People with allergies may be more sensitive to high temperatures, severe cold and major temperature fluctuations than non-allergic individuals (Hult and Persson, 1991). An excessively low

temperature may cause direct health effects such as rheumatism and impaired muscular function. Excessively high temperature may cause fatigue, impaired work performance and higher accident risk. In laboratory experiments, air temperature and relative humidity have also had a strong impact on the perception of air quality (Fang et al., 1998).

3.3 Air quality

Air quality is very important to health, and WHO has underscored people's right to healthy air (Mølhave and Krzyzanowski, 2000). According to a review of the literature (Wargocki et al., 2001) there is support for the following; greater incoming air flow improves perceived air quality, incoming flows of up to 25 l/s per person reduce the risk of SBS symptoms and short-term illnesses and increase productivity and finally that a 0.5/h air replacement in homes reduces the incidence of mites in the Nordic countries. Indoor air quality is affected by numerous factors. Those discussed below are relative air humidity, gaseous and particulate pollutants from outdoor air, chemical emissions from building materials, microorganisms, house dust mites and radon from the soil.

3.3.1 Relative air humidity. Moisture in the air may condense on cold surfaces and in structures, which may lead to microbial growth and chemical reactions/breakdown and cause chemical emissions. It is unclear what correlations exist between relative air humidity and health effects, aside from house dust mites. Experience points to moisture ratio as an indication of moisture problems.

3.3.2 Gaseous and particulate pollutants from the outdoor air. Our main exposure to gaseous and particulate pollutants from the outdoor air occurs indoors (Victorin et al., 2001). Ozone is an exception, since the indoor level is usually lower than outdoors. Various studies have shown that short-term variations in air pollution levels outdoors have co-varied with lung function, asthma and bronchitis symptoms, lower respiratory symptoms in children, hospitalizations and mortality (Victorin et al., 2001). Three American studies have noted long-term elevated mortality in areas of high air pollution levels, mainly linked to particulates (Victorin et al., 2001). According to one epidemiological study, air pollution may probably also cause lung cancer. It is important to distinguish between short-term and long-term effects. Exposure to particulates occurs when they are inhaled. The health effects depend mainly on the type and quantity of inhaled particulates, as well as how long inhalation has lasted. Medical interest has recently focused on the very smallest, so-called $PM_{2.5}$ particulates, which pass all the way down to the alveoli when inhaled. To summarize, we know little about the health effects of gaseous and particulate pollutants, what mechanisms are involved and the effect of exposure time. It has not been possible to demonstrate any threshold effect, i.e. a "safe level" below which no one's health is affected (WHO Regional Publication, 2000).

3.3.3 Chemical emissions from building materials. Building materials may cause chemical emissions into the indoor air. It is believed that asthma and sensitization may be caused by certain reactive organic substances, and probably in very low concentrations (Sundell and Kjellman 1995). Respiratory irritants can probably be formed from reactions between oxidants and unsaturated volatile organic compounds (VOCs) such as terpenes (Wolkoff et al., 2000). Concentrations of ozone and certain reactive VOCs in indoor air should thus be restricted. In selecting building materials, the material with the lowest emissions should be chosen, according to the principle of caution. However, there is no general definition of what "low-emission material" means. Overall, we do not know what substances adversely affect health and how they may affect health.

3.3.4 Microorganisms. The occurrence of moisture is one precondition for microbial growth (Hallenberg and Gilert, 1993). Microorganisms themselves are not a major health risk, but rather the spores and secondary metabolites they produce. A reaction to mold may manifest itself in a number of symptoms and will depend, for example, on exposure (concentration and time) and on factors specific to the mold species (occurrence of toxins, size of spores etc.). We know that damp buildings pose increased risks, mainly of respiratory symptoms (cough, labored breathing and asthma), but also of other health effects in the form of unspecified symptoms like fatigue and headache (Bornehag et al. 2001). We do not know, however, what mechanisms cause these health effects. There is also no general definition of what a "damp building" means. Existing knowledge is not always used, and there is a lack of generally accepted objective procedures for how to inspect and evaluate moisture and mold damage.

3.3.5 House dust mites. Problems with house dust mites occur mainly in countries with warm and humid climates, but also in the Nordic countries (Sundell and Kjellman, 1995). Our knowledge of what allergic problems are caused by house dust mites is good. These problems may manifest themselves in the form of asthma, allergic hay fever or eczema (Sundell and Kjellman, 1995).

3.3.6 Radon. The main source of radon is the soil. Radiation from radon daughters can damage the lungs and cause lung cancer, especially in combination with tobacco smoke. For this type of radiation, a linear correlation is assumed between dose and cancer risk (Pershagen et al., 1993). At average radon levels of 140-400 Bq/m^3 the increased risk of lung cancer was about 30% and at levels above 400 Bq/m^3 the increase was about 80%, compared to those who had an average concentration of no more than 50 Bq/m^3. For a non-smoker, this is equivalent to an average risk increase of 0.2%, provided that the lifetime risk of lung cancer in non-smokers is 0.7% (Victorin et al., 2001). Our knowledge is good, and as a rule there are clear standards.

3.4 Electric and magnetic fields

It has not been possible either to confirm or reject suspicions that higher levels of magnetic fields might increase the risk of developing certain forms of cancer (National Radiological Protection Board, 2001) (Victorin et al., 2001). WHO's cancer research institute has classified magnetic fields as a possible carcinogen. Electro hypersensitivity has been discussed as an environmentally related set of problems, apart from discussions of cancer. The symptoms are not specific, but instead may occur together with other known illnesses (Persson et al., 1998). Today there is no clinically evaluated method for objectively testing electro hypersensitivity. The fact that no correlations have been proven does not mean that they do not exist or can be ruled out.

3.5 Lighting

Lighting governs our daily and seasonal rhythm. Insufficient access to daylight may lead to physical or mental illness (Sundell, 1999). There are various recommendations on how a completed building should function in terms of light, as far as daylight and fixed illumination are concerned.

3.6 Noise

The health effects of noise can be divided into primary and secondary effects, i.e. a combination of general discomfort and bodily imbalance (Victorin et al., 2001). The effects may consist of sleep disruption, impaired ability to perceive and understand speech and difficulty in concentrating. There are also suspicions that high-level exposure to outdoor noise

may cause blood pressure-related illnesses (Victorin et al., 2001). Noise classification standards make it possible to design homes with a more or less good noise environment.

4. CONCLUSION

Air quality is influenced by the largest number of factors and has probably the greatest influence on health. Health affects in the form of hypersensitivity- and illness-related problems as well as discomfort. Aside from electrical and magnetic fields, we know the least about air quality. Moisture mechanisms co-vary with the occurrence of microorganisms, chemical emissions from building materials or house dust mites. The external environment surrounding is important, since gaseous and particulate air pollutants in outdoor air and radon from the soil leak in and affect the indoor air. The Swedish building code and other recommendations are based on what we know or what we believe. They take health effects into account in varying degrees.

5. DISCUSSION

This compilation of knowledge shows large gaps in knowledge, mainly regarding air quality as well as electrical and magnetic fields. As for health effects, it is important to note that although we humans may seem so alike, we react differently. Knowledge regarding health effects should therefore be graded by sensitivity, for example in the case of gaseous and particulate air pollutants, compounds from building materials and biological compounds. When scientific evidence is lacking, we should rely on common sense and practical experience, instead of letting chance dictate until the pieces of the scientific puzzle fall into place.

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Planning project for sustainable building in Catalonia

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1. INTRODUCTION

The aim of this document is to set out how the Programme to promote planning and sustainable building (PPSB) has been developed in Catalonia. We understand that from a planning perspective it is necessary to show which were the objectives encouraging the Government of Catalonia to apply this Programme, how the actions to reach these objectives were developed and which were the difficulties we found during the process, so that our experience could be used as an example for other institutions interested in carrying out a similar initiative.

1.1 The construction industry in Catalonia

The construction industry is important in Catalonia: it represents a 7.3% of the GDP, giving work to the 9% of the population. This situation motivates the administration to promote the principles of sustainability in this industry. This industry is technically regulated but not from an environmental point of view. We can find some general references in recent Catalan regulations, for example, in the new Law 2/2002 of March 14th on urbanism[1]. Another example can be the Environmental Impact Evaluation[2], which is consolidated for infrastructures but not for buildings.

1.2 Background in the construction industry and sustainable planning

Before the concretion of the PPSB, The Government of Catalonia had been working in some aspects related to sustainable construction that can be seen in publications (e.g. *Sustainable criteria for edification*[3]), regulations (e.g. Decree on water[4], introduction of other specific environmental subjects, most of all on energy), pilot projects (e.g. Trinitat Nova[5]), promotion (e.g. Support to the web of the College of Quantity Surveyors[6]) and sensitisation campaigns (e.g. Campaign *Catalonia saves water*[7]), among others. But a new integrating promotion of all efforts done until then was needed: a promotion that would originate a structured and coherent planning in answer to environmental problems.

The first step consisted in co-ordinating the different departments of the Government of Catalonia that, because of its competencies, were working in specific aspects on planning and construction. So, in July 2001, a Framework Agreement of Collaboration was signed by the Department of Industry, Trade and Tourism, the Department of Territorial Policy and Public Works and the Department of the Environment to develop different activities for environmental improving in planning and construction fields in Catalonia. In this agreement

was also settled the creation of a working group with technicians from the three departments. This group should promote the exchange of experiences and future collaboration.

2. MAIN AIMS ESTABLISHED BY THE PROGRAMME

The working group had a primary diagnosis of resources with consumption indicators associated to construction: urban areas consume a 40% of energy, a 25% of water and a 30% of raw material.

The main aim of the programme is to reduce environmental impact improving the resources use and the waste production efficiency. This general objective can be concrete in: avoiding unnecessary occupation of soil, reducing water consumption to strictly necessary, reducing CO_2 emissions associated to inefficient energy consumption, using retrained material and construction materials to be retrained, improving environmental quality in buildings and also the integration of urban emplacements in the landscape.

To develop these objectives four strategies have been established: *agents involvement, introduction of environmental criteria in urban and land-use planning, environmental improving of buildings and development of certification systems*. These four general subjects can include all necessary interventions to give an impulse to the PPSB in a coherent and integrated way.

3. AGENTS INVOLVEMENT

The initiatives carried out by the Department of the Environment can not be understood without considering that the most important aspect of the project is to achieve a positive predisposition and a progressive responsibility of all agents related to it, so that all of them can work in a more effective way to consolidate a sustainable planning and construction. That's why the first step was to elaborate an exhaustive list of these agents. Afterwards, we began contacts to explain the PPSB and to find the best way to collaborate with them.

3.1 Collaborations with every agent

The following are the results of the contacts started with the agents.

3.1.1 Regional and local public administrations have an essential role in the configuration of urban areas and, so, in the design of urban occupation of soil and in the conditions required in future buildings. That means it is essential to involve administrations in the project so that they assume their role as a model and example for the construction industry.

The Department of the Environment is working in this way promoting the inclusion of the PPSB in local 21 Agendas and establishing specific collaborations with some city councils that had a positive predisposition to the project.

Building promoters have a decisive intervention in building process. It is then important to involve these companies to assure the consolidation of environmental criteria in the building process. To begin working together with promoters, collaboration agreement has been signed with the Building Promoters and Constructors Association of Barcelona. An example of this co-operation is the sensitisation of consumers that is doing the Administration so that the promoter interested in including environmental improving in his building can have a competitive advantage.

The builder carries out building construction and rehabilitation. In this case an agreement with the Chamber of Builders is going to be approved. One of the first results of the implication of the builder's sector is the book *Good practices in the construction area*[8] recently edited.

Professional colleges are directly related to the construction. Their participation is absolutely needed to manage the implication of professionals in the project. The Environment Department has an agreement with the College of Quantity Surveyors to develop a web on sustainable buildings[6].

Research agents are important for their capacity to investigate on new technologies. There is a permanent collaboration with these agents. One example of that is the collaboration agreement to deepen in the knowledge of environmental characteristics of materials included in the *White book of materials*[9], and it will be useful for a future ecolabel of them.

Social agents through foundations, ONG's and associations like consumer's association among others have an essential role for the acceptation of the importance of the programme in society and trade.

We have also to underline the **private sector** which is not directly involved in construction but can include important environmental improving in their management: managerial associations, chambers of commerce, etc.

The relations established for the implication of these agents are directed to three main sections:

3.2 Professional training

3.2.1 Training for construction and planning professionals. The aim of this work is to promote good environmental practices within this area. The decisions and actions that are developed daily by every one of the agents are decisive and, therefore, they require a concrete orientation using guides and conduct codes. Specific results of collaboration between the Department and the Construction Company already exist. The book *Good practices in the construction area*[8] has just been published, and seminars are been developed for the extension of environmental management systems in the construction area (through those exemplary companies which have obtained the EMAS), etc.

On the other hand, there is an agreement between the Department of the Environment, The Department of Work and the Gaudi Institute to include environmental perspective in training courses for professionals.

3.3.2 Professional training for new professionals. Curriculum on environment is a key piece in a mid and large period to ensure that new professionals can have, since the beginning of their studies, enough technological knowledge and environmental awareness to ensure the progressive and extensive implementation of the most sustainable technical solutions.

3.4.2 Information

The information system which is being shaped is based itself in community resources produced in the rest of work lines and it is expressed itself through different publications on

the subjects we deal in the programme and with telematics development through the Website of the Department of the Environment[10] which includes a specific sector referring to the programme where new results have been produced.

As for the indicators system for self-control programmes, action indicators have been planned (number of agreements, seminars and publications and new projects we started) and result indicators, which are directly referred to the programme's aims, they summarise the information referring to sustainable buildings which have been built to assess the effectiveness of environmental measures introduced.

4. INTRODUCTION OF ENVIROMENTAL CRITERIA TO URBAN AND LAND-USE PLANNING

A very important second strategic line, especially in mid and long term, is to insist in urban planning to ensure the introduction of environmental criteria for the use of soil and the regulations for construction are carried out in the first steps of the project.

4.1 Practical guide of sustainable planning

A practical guide for planning officers is being developed. It includes:

- Sustainable urbanism concept defining technical prescriptions that different kinds of plans must have (technical and environmental memory, cartography and regulations)
- Concretion of a sustainable model to use the soil: from the systems' definitions, the development of soil not allowed to be urbanised...forming a legend that ensures the inclusion of environmental criteria in the planning.
- Model of sustainable use for other resources: water, atmosphere, materials, wastes...

4.2 First experiences in general pilot planning

On the other hand, we are working in a general pilot planning including the most advanced models, criteria, systems and regulations for environmental improvement and environmental efficiency, to be used as an example for other projects to be developed in short- term.

5. ADAPTING BUILDINGS TO THE ENVIROMENT

A third strategic line is emphasising in environmental improvement of public buildings, to ensure they can be used as a sustainable building model. The objective is to make these improvements extensive to private buildings

5.1 Development of the most effective technologies

A line work between public administration and professional centres area is focused in defining and stating the most effective systems and measures to improve environmental quality in different kinds of the existing buildings and the new ones. For example, to make good use of water coming from the rain for toilets or irrigation, to save irrigation water in green areas, reuse of domestic waste water (*grey water*), separative systems, extensive application of saving water mechanisms, advantage of solar energy, improvement of energy efficiency in buildings, use of retrained materials, etc. The results of this work will be collected in a file card to be used by any professional interested in knowing the last advances in buildings construction. We are carrying out guide projects in buildings to assess environmental and economic efficiency of technologies and systems to improve buildings environmental behaviour.

5.2 Progressive introduction of environmental criteria in technical prescriptions

To insist in improving the environment in technical prescriptions is one of the most innovative actions to promote environmental improvement in the construction industry. In our present situation projects are given from the administration in accordance with technical and economic criteria. We are promoting to include environmental criteria so that they mean an important rate when we contract a project, a work, etc.

5.3 Municipal plans to adapt buildings to the environment

One of the most ambitious objectives of this line of work is to elaborate, at a local scale, municipal plans to adapt buildings to the environment. This scale allows the development of good diagnosis of the situation, planning and construction. It allows to state the measures promoted by the PPCS and insist in new aspects like to carry out bylaws and promote the application of environmental measures in the private sector through fiscal advantages which reduce administration costs for professionals having the option for a better environmental quality.

6. DEVELOPMENT OF CERTIFICATION SYSTEMS

Finally, a fourth strategic line is focused in the development of certification systems motivating environmental improvement in the construction industry. Its possibilities are the following:

6.1 To promote the EMAS

The aim is to apply the EMAS in buildings like tourist centres, health centres, education centres, etc. in a way that involvement and efficient environmental management in projecting and using buildings is guaranteed.

6.2 To promote and develop the Emblem of environmental quality

To those products and systems related to construction: elements to save water and energy among others.

We are developing the ecolabel for materials, which will help to the efficient election of those with less environmental impact. In this sense we are working in the *White book of materials*[9] where characteristics of materials referring to its environmental impact are described.

7. PRESENT RESULTS AND FUTURE EXPECTATIONS

Now we are able to assess whether the efforts carried out these years have had a positive incidence in an environmental improvement in the planning sector and the construction industry. The network among the agents is consolidating and we will see its results starting from 2003. We will have an assessment of the PPCS reach with the first data of the indicators system starting from 2002, and we can suppose a generalised introduction of the most efficient systems by the end of 2004. The final horizon of this programme is in 2010.

7.1 Development of a decree on planning and sustainable buildings

One of the aims at medium term is to consolidate the most important measures to achieve a sustainable planning and buildings through a global decree improving the present trend of regulating the industry only in precise aspects (examples: the decrees regulating independently some systems to save water, solar energy, etc., without considering the constructive process from the planning until the building use).

8. CONCLUSION

The Programme to Promote Sustainable planning and Building wants to change habits in professional and construction systems. This means to follow two main aims: greater agents' involvement and improving of environmental aspects. We have to point out that the administration is going to emphasise in the private sector after involving all regional and local public administrations. A learning way in this sense is to find international collaboration to exchange experiences, instruments and strategies in this line. We hope this manuscript will help managing this last objective.

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Sustainability of Multiple Recycling of Coarse Stone Aggregates in Concrete

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1. INTRODUCTION

In the last fifteen years, public authorities' focus on construction and demolition waste (CDW) has been reflected in the arising of a great number of working groups, conferences, seminars and strategy action plans in the theme of construction and the environment. Other repercussions were the approval of specific legislation, the appearance of financial resources for research and investments in the CDW recycling industry (Vasquez 2000).

According to the progress report made by the Symonds group (UK) and presented in 1999, the production of CDW in the EU reaches approximately 180 Mt per year. Of this total, 28% are recycled and the remaining is dumped. In Portugal, as well as in Spain, Greece and Ireland, according to this report, less than 5% of the global volume of CDW produced is recycled (ETN 1999).

In countries such as the Netherlands, the UK, Belgium, Germany and Norway, there are case studies of the use of coarse concrete aggregates in the production of new concrete to be used in structural members. In most cases, only a fraction of the natural aggregates was replaced in the concrete composition by recycled ones. However, there are references to a good performance of concrete made with 100% recycled coarse aggregates (ETN 2000).

This paper presents the initial results of a wider research program in course at Instituto Superior Técnico (IST) in which the compressive strength of consecutive series of concrete cubes containing coarse aggregates recycled from previous series was measured.

2. LABORATORY TESTS

2.1 General remarks

Concrete represents around 75% (in terms of weight) of all construction structural materials and is responsible for a great percentage of waste from demolitions. Millions of tons of concrete waste are also produced through natural catastrophes. The excessive demand on natural resources, laws progressively more environmentally minded and problems with waste dumping are factors that contribute to make concrete waste reutilization an interesting option.

After crushing, concrete may be used as coarse aggregate for new concrete. However and even though not all the original cement has been hydrated, it is necessary to use the same or even a bigger cement content than for making concrete with natural aggregates.

In the study presented here, the concrete waste used in the first tests cycle came from test cubes obtained from LNEC (the Portuguese National Laboratory of Civil Engineering). Most of the properties of this concrete, such as the slump and the water/cement ratio, were unknown. Only the compressive strength and its characteristic value, f_{ck}, had been determined. This fact impaired comparisons with reference concrete made with natural aggregates only concrete. Nevertheless, it portrays a realistic situation, such as when a structure is being demolished and nobody knows the properties of the materials (very often, not even the concrete strength).

The main objective was to analyse the strength of concrete produced with coarse recycled concrete aggregates. The original test cubes were therefore crushed in order to obtain recycled aggregates, new cubes were made, tested, crushed, and so on.

2.2 First recycling cycle

As referred, the coarse aggregates used in the first cycle of testing were obtained from test cubes made with natural aggregates and tested at LNEC. These cubes were later taken to a recycling plant (Lobbe) and were crushed into aggregates (Figure 1).

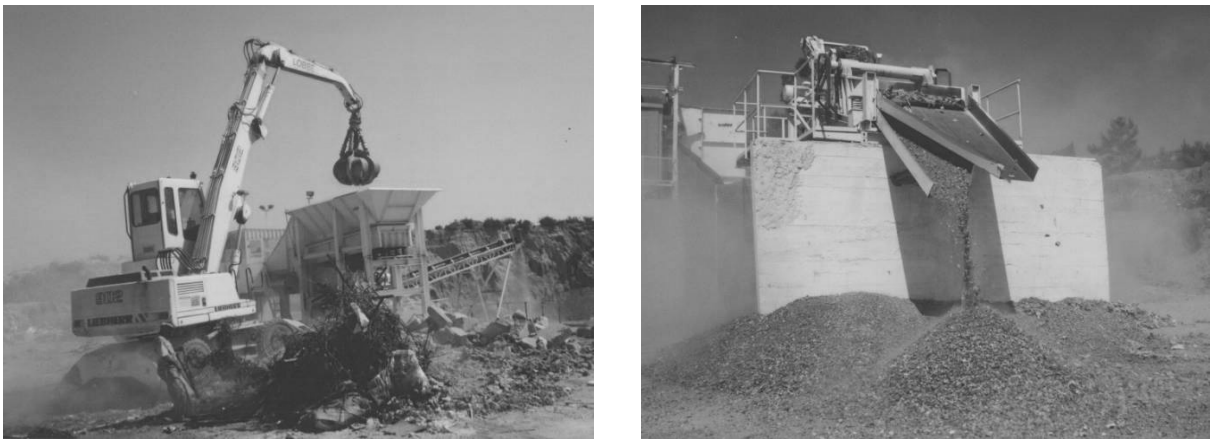

Figure 1 Recycling plant (left) and aggregates made from the cubes (right).

At the Construction Laboratory of IST, this material was sieved in order to extract the fine aggregates, since it was decided from the beginning that in this study they would not be reused. Some residual materials were extracted by hand. All aggregates of much too great dimension and the ones that were not reused, as well as the fine aggregates, were weighed, in order to measure the potential of reuse of the aggregates.

The mixing composition of the concrete in the first recycling test, with a slump of 2.8 cm, was as follows:

cement: 450 kg/m^3; natural sand: 730 kg/m^3; coarse recycled aggregates: 1040 kg/m^3; w/c: 0.45; plasticiser: 2.4 l/m^3.

After mixing and having accepted the slump value obtained, 30 moulds were filled with the

fresh concrete. These had been previously cleaned and sprayed with a release agent. After 24 hours, the cubes were demoulded and stored in a curing chamber at 20ºC and a relative humidity of around 100% for a further 27 days (Figure 2, left). After this time, they were subjected to a compressive strength test (Figure 2, right), where the value of f_{ck} = 42 MPa was obtained, corresponding to a C32/40 concrete.


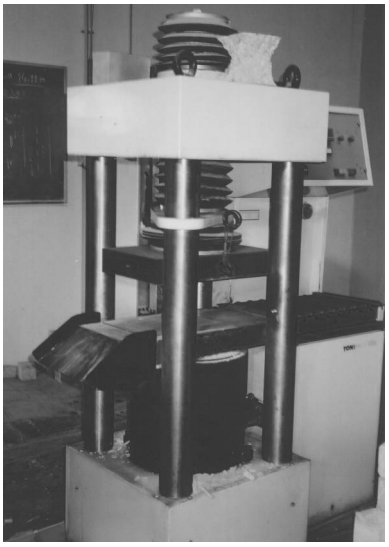

Figure 2 Test cubes in the curing chamber (left) and compressive strength testing apparatus (right).

2.3 Second recycling cycle

For the concrete of the second recycling cycle, the same concrete mixing composition was used and the coarse aggregates were the ones obtained from the crushing of the cubes of the first cycle (Figure 3, left). Since a slump of 5.5 cm was obtained, a value unexpectedly high when compared with the one from the first cycle, in the second and third mixes of this cycle only 1.6 l of plasticiser was used per cubic meter of concrete (down from 2.4 l). However, an mean slump value of 5.3 cm was obtained (Figure 3, right), a trade that can be explained by the unusually high humidity during this cycle or by the possible use of damper sand.

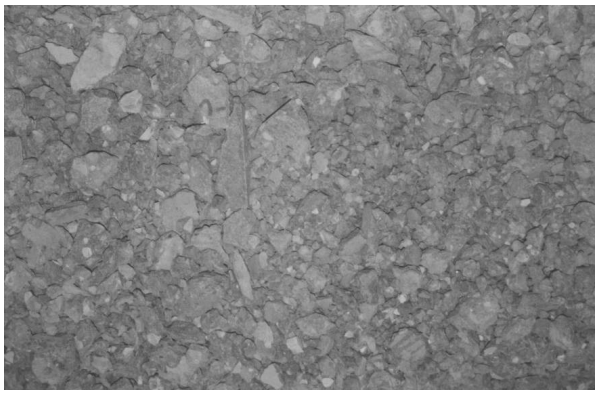
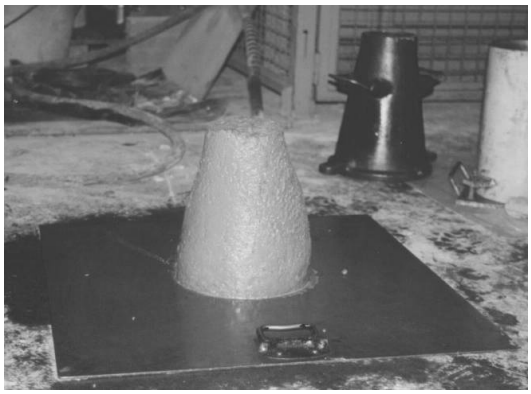

Figure 3 Crushed concrete (left) and Abrams cone test (right).

After 28 days, the second set of 30 cubes were tested in compression, and characteristic values of 40 MPa (1st mix) and 38 MPa (2nd and 3rd mixes) were obtained, corresponding in terms of compressive strength classes to C32/40 and C30/37 concretes, respectively.

2.4 Third recycling cycle

In the third cycle, two mixes were made with the same mixing composition as the first cycle and the 2nd mix of the second cycle, for which the mean slump obtained was 3.3 cm. In order to understand the influence of the cement content in the results, in the 3rd mix it was decreased as well as the amount of plasticiser agent. For this last mix, where a slump of 1.0 cm was obtained, the mixing composition was:

cement: 400 kg/m^3; natural sand: 730 kg/m^3; coarse recycled aggregates: 1040 kg/m^3; w/c: 0.45; plasticiser: 2.13 l/m^3.

In this third cycle, different results were expected by comparison with the ones from the second cycle. This difference had to do with the lower content of cement and plasticiser (only in the 3rd mix) and with the lower percentage of finer coarse aggregate resulting from the crushing process used in all the mixes of this cycle (and different from the one used in the first two cycles). This time the cubes were crushed in a small crusher of the Mines Department of IST (Figure 4, left). Given the characteristics of the apparatus, crushing had to be performed twice with different sieves, thus producing a lower quantity of the finer part of the coarse aggregates to be recycled than in the first two cycles (Figure 4, right). These two trades pointed in opposite directions in terms of compressive strength expected. The lower content of cement and plasticiser seemed to reduce it, but the smaller content of the finer coarse aggregates reduced the water absorption and therefore increased the expected strength.

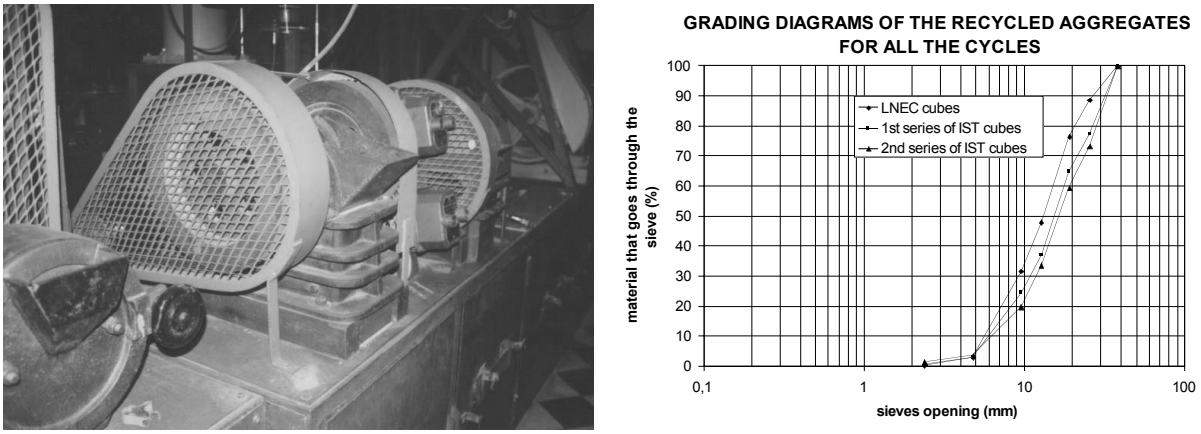

Figure 4 Small crushing unit (left) and grading diagrams of the coarse recycled aggregates used in the recycling cycles (right).

After another 28 days, the cubes were tested in compression and a value of f_{ck} of 46 MPa was obtained (for all the mixes), thus corresponding to a C35/45 concrete.

3. ANALYSIS OF THE RESULTS

In order to put into perspective the cycles described before, Table 1 presents the main results obtained (only for the mixes where the composition was the same as in the first cycle).

Table 1 Summary of the results obtained in the three recycling cycles (Gonçalves 2000).

CYCLE	SLUMP	COMPRESSIVE STRENGTH	CONCRETE CLASS	COARSE AGGREGATES WATER ABSORPTION
1st	2.8 cm	42 MPa	C32/40	6.3 %
2nd	5.3 cm	40 MPa	C32/40	7.6 %
3rd	3.3 cm	46 MPa	C35/45	8.5 %

The slight strength reduction between the first and the second cycles can be explained by:

- due to different weather conditions, the aggregates were damper in the second cycle, also perhaps because they were taken from the outer layers of the aggregates deposits;
- in the first cycle, the working process was rather tentative and slow, contrary to what happened in the second cycle;
- the cement used in the second cycle had been stored for a long time and perhaps was not in the best conditions.

In what concerns the results from the third cycle, they were slightly better than expected, probably due to the difference in the grading of the aggregates due to the change in the crushing apparatus, leading to a better compaction factor.

About 20 to 30% of the cement is not hydrated during mixing. This may have some importance in the production of concrete with aggregates recycled from demolished concrete, since the crushing process may release unhydrated cement particles that may subsequently react. This trade could explain the results in the third cycle. However, some other experimental results point the finger at the effective water/cement ratio changing with the recycled aggregates effective water absorption, thus conditioning the strength results obtained.

Therefore, it is supposed that the small fluctuations around the C32/40 class in the concrete strength in the various cycles are due simply to the difficulty in maintaining constant several characteristics, such as the water content of the fine and coarse aggregates, the environmental relative humidity, the cement quality, the mixing time, the aggregates grading, among others.

Besides the results presented above, there are other conclusions that can be reached from a global analysis of the three recycling cycles performed, namely:

- the water absorption of coarse recycled concrete aggregates is a fundamental aspect to be taken into account in the production of new concrete; the higher or lower absorption will condition the workability, which in this study was corrected by adding plasticisers and increasing the cement content;
- the amount of plasticiser used had a direct, if not very pronounced, influence in the concrete strength;
- using type I cement instead of type II may lead to better results, since a reduction of around 30 kg per cubic meter of concrete could be expected;
- if a better quality cement were to be used, a superplasticiser agent would be recommended;
- everything indicates that a 100% repetitive recycling of the coarse aggregates from demolished concrete is sustainable in terms of strength; furthermore, the amount of coarse recycled aggregates obtained from a predetermined volume of demolished concrete is more than enough to produce an identical volume of concrete; in economic terms, the disadvantages of having to use a plasticiser (to maintain the workability without increasing the w/c ratio) and of using a higher cement content in the first cycle only (change from a concrete made with natural aggregates only to one made with recycled coarse aggregates) will have to be taken into account.

These three recycling cycles are only a first step. As a matter of fact, the relatively small number of cubes and cycles and the variations in the weather conditions impose the need of a

broader work in order to confirm the main conclusions obtained here and to explain unexpected results such as:

- the reduction of the amount of plasticiser in the 2nd and 3rd mixes of the second cycle did not lead to a reduction in the slump;
- for the same mixing composition, fluctuations in the workability were noticed, possibly caused by changes in the weather conditions and, consequently, in the materials (sand and cement) themselves;
- in the 3rd mix of the third cycle, a reduction in the cement content (50 kg/m^3) and in the amount of plasticiser did not result in a loss of concrete strength.

4. GENERAL CONCLUSIONS

In what concerns the experimental results, it can be concluded that the process of recycling coarse aggregates from demolished concrete is basically self-sustainable. In fact, it was possible to maintain the strength and workability characteristics in successive cycles of production of new concrete with demolished concrete recycled coarse aggregates. For that, small changes were made in the cement content (only in the first cycle) and a plasticiser was added. It must also be referred that the fact that the w/c ratio was kept constant throughout the whole process, notwithstanding the constant increase in the water absorption of coarse recycled aggregates (Table 1), gives good reasons to think that the durability of the concrete made with these aggregates will not be inferior to the one from conventional concrete.

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Mechanical Properties of Concrete with Coarse Recycled Concrete Aggregates

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1. INTRODUCTION

The growing awareness regarding environment and natural resources shortage has recently led to a sustainable alternative. The recycling process appears as a good way to minimize the use of natural resources and to solve the problem of the lack of disposal sites caused by the large amount of waste dumped.

Recycling of construction and demolition waste (CDW) has come up as a way of reducing the waste harmful effect in the urban environment through the use of CDW recycled aggregates in new products such as road pavement bases, concretes and mortars. In order to introduce this type of waste in the market, it is necessary to investigate it in scientific terms, to know its contamination risks and to find its potential applications, taking into account its quality, limitations and the technical-economical aspects that characterise it. Concrete waste is seen as an alternative source of raw materials in conventional concrete through the incorporation of recycled concrete aggregates.

This paper presents a research work that has been developed at the Technical University of Lisbon (IST), concerning the properties of concretes made with coarse recycled concrete aggregates. Two coarse recycled concrete aggregates (RCA1 e RCA2) were produced from original concretes cast at the laboratory with different compositions. Initial characterization tests were performed on both the coarse recycled and natural aggregates (NA) and the results compared. Afterwards, each one of those groups of RCA was used to cast two different types of concrete, replacing the entire amount of coarse NA. Compressive strength, Modulus of elasticity and drying shrinkage of these concretes and a conventional concrete were assessed and compared.

2. MATERIALS UNDER INVESTIGATION

2.1 Aggregates

In this work two types of original concrete were cast to examine their influences on both RCA characteristics and the mechanical properties of new concrete produced with these aggregates.

The Portland cement used was type II, grade 32.5 MPa according to NP 2064. For the coarse natural aggregate (NA), limestone fraction 4.76/19 was chosen and for the fine river sand. The mixing proportions and compressive strength of original concretes were:

To produce RCA1 - *cement = 410 kg/m^3, coarse aggregate = 1266 kg/m^3, fine aggregate = 545 kg/m^3, water/cement ratio = 0.4, 29-day compressive strength = 56 MPa;*
To produce RCA2 - *cement = 350 kg/m^3, coarse aggregate = 1117 kg/m^3, fine aggregate = 743 kg/m^3, water/cement ratio = 0.49, 29-day compressive strength = 45 MPa.*

Both RCA1 and RCA2 were obtained crushing cylinders and cubes cast from original concretes. The jaw crusher used is shown in Figure 1.



Figure 1 Jaw crusher used to produce coarse recycled concrete aggregates

2.2 Concrete

In this work the aim was to compare mechanical properties like compressive strength, Modulus of elasticity and drying shrinkage of conventional concrete mixes made from NA with those of similar mixes incorporating RCA. Both NA and RCA concrete mixes were proportioned following a practical mix design method (Helene, 1994). The workability (determined with the slump test) was maintained constant in all concrete mixes. The coarse and fine aggregates used in NA concrete mixes had the same origin and grading as those applied in original concrete mixes. The mixing proportions of NA concrete were:

NA concrete - *cement = 361 kg/m^3, coarse aggregate = 1072.17 kg/m^3, fine aggregate = 696.73 kg/m^3, water/cement ratio = 0.56.*

In both RCA1 and RCA2 concrete mixes the coarse aggregate contents were adjusted to maintain the same volume of coarse aggregates of the NA concrete and the fine aggregates used in these mixes were the same river sand. In order to limit the number of variables when analysing the test results, it was decided to use RCA with similar grading as the NA ones. The mixing proportions of RCA1 and RCA2 concretes were:

RCA1 concrete - *cement = 361 kg/m^3, coarse aggregate = 981.03 kg/m^3, fine aggregate = 696.73 kg/m^3, water/cement ratio = 0.65;*
RCA2 concrete - *cement = 361 kg/m^3, coarse aggregate = 970.34 kg/m^3, fine aggregate = 696.73 kg/m^3, water/cement ratio = 0.65.*

When recycled concrete aggregates in air-dry state are added to a paste or mortar, it is supposed that they will absorb a part of the water that is added when mixing the concrete. The amount of water that the recycled aggregates will absorb depends on their characteristics and also on the consistency of the paste or mortar.

As the use of recycled aggregates in saturated surface dry condition is very difficult, it was decided to use them in air-dry condition and evaluate the effective coefficient of absorption (Barra, 1998). The recycled aggregates were initially mixed with water during a certain time and afterwards cement and sand were added, in this order.

3. TESTS ON AGGREGATES

Standard tests to evaluate some properties like grading, absorption, and apparent specific and bulk density of fine and coarse aggregates (natural and recycled) were performed. The effective coefficient of absorption of coarse recycled concrete aggregates was assessed using a method described by Barra (1998).

According to that technique some samples of recycled aggregates with contents of water evaluated at the date of mixing were hand mixed (Figure 2) with water in the same time interval that the concrete mixes. The amounts of aggregate and water were proportional to those used in the mixes. After the aggregates had been mixed with water it was possible to evaluate the amount of water absorbed and the effective coefficient of absorption of recycled concrete aggregates. The properties of fine and coarse aggregates are shown in Table 1.

Table 1 Properties of fine and coarse aggregates

PROPERTY	FINE AGGREGATE (RIVER SAND)	COARSE NATURAL AGGREGATE (LIMESTONE)	COARSE RECYCLED CONCRETE AGGREGATE (RCA1)	COARSE RECYCLED CONCRETE AGGREGATE (RCA2)
Dry specific density (kg/m^3)	2504 (NP 954)	2626 (NP 581)	2364 (NP 581)	2329 (NP 581)
Saturated surface dry specific density (kg/m^3)	2527 (NP 954)	2657 (NP 581)	2480 (NP 581)	2458 (NP 581)
Bulk density (kg/m^3)	1513 (NP 955)	1534 (NP 955)	1372 (NP 955)	1393 (NP 955)
Porosity (%)	-	3 (NP 581)	11.6 (NP 581)	12.9 (NP 581)
Water absorption (%)	0.9 (NP 954)	1.14 (NP 581)	4.9 (NP 581)	5.5 (NP 581)
Effective water absorption (%)	-	-	1.7 (BARRA 1998)	1.82 (BARRA 1998)
Water content (%)	-	-	2.46 (NP 956)	2.83 (NP 956)
Maximum size (mm)	1.19 (NP 1379)	19 (NP 1379)	19 (NP 1379)	19 (NP 1379)
Fineness modulus	1.99 (NP 1379)	6.73 (NP 1379)	-	-



Figure 2 Mixing of a sample of recycled aggregate with water

The coarse recycled aggregates exhibit higher water absorption than the natural ones mainly due to its also higher porosity (Table 1). The mortar of the original concrete attached in recycled concrete aggregates causes their higher porosity. This mortar is also responsible for the lower densities of recycled aggregates and the wider range of density variations when compared with coarse natural aggregates.

There are no great differences in water absorption, porosity and density values between RCA1 and RCA2 (Table 1). The higher porosity and water absorption of RCA2 and the lower specific densities can be explained by the higher dry mortar content of RCA2 original concrete, 49.4 % compared with 36.3 % of RCA1 original concrete.

4. TESTS ON CONCRETE

The three concretes (NA, RCA1 and RCA2) were prepared with the same methodology. For each concrete type, several specimens were cast. In all concrete mixes the workability (slump) was fixed at 85 ± 10 mm. The properties of fresh conventional and recycled concretes evaluated in this work are given in Table 2.

Table 2 Properties of fresh concrete

CONCRETE	WATER/CEMENT RATIO [*1]	EFFECTIVE WATER/CEMENT RATIO [*2]	SPECIFIC DENSITY (kg/m^3)	SLUMP (mm)
NA	0.56	0.56	2366	85 ± 10
RCA1	0.65	0.60	2287	85 ± 10
RCA2	0.65	0.60	2282	85 ± 10

[*1] water/cement ratio for the total amount of water added during concrete mixing
[*2] water/cement ratio for the effective water content in the cement paste

The lower specific densities of RCA1 and RCA2 concretes when compared with NA concrete can be explained by the lower specific densities of recycled aggregates. There is little difference between the specific density values of RCA1 and RCA2 concretes (lower value in RCA2 concrete) as expected behaviour because the specific density of RCA2 was also marginally lower.

The properties of hardened concrete studied in this work were compressive strength, Modulus of elasticity and drying shrinkage. All specimens were demoulded 24 hours after casting. The compressive strength was evaluated using 15 cm cube according to LNEC E 226. The cubes were cured in a moist room until the test. A comparison of 7 and 30-day compressive strengths for all concrete mixes is shown plotted in Figure 3.

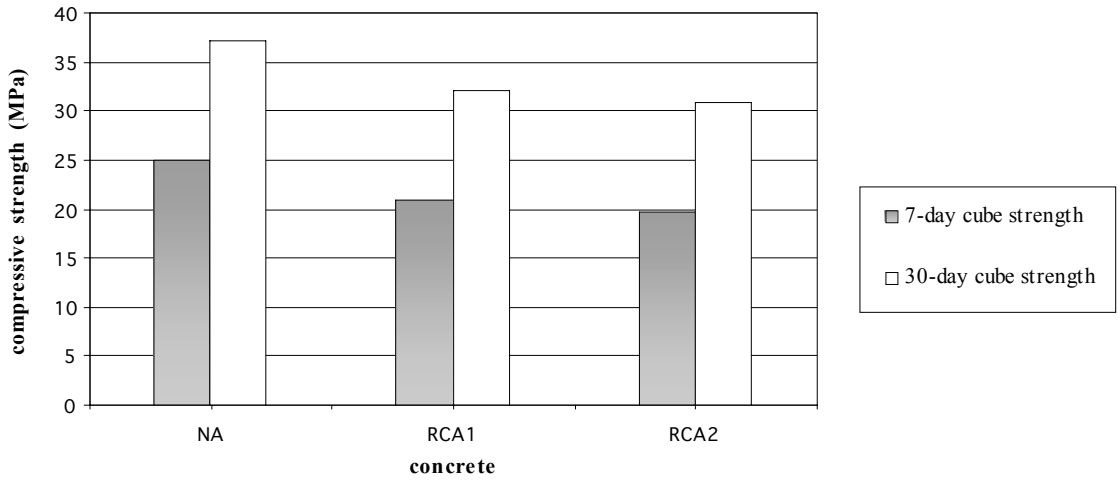

Figure 3 7 and 30-day compressive strengths of all concrete mixes

Lower compressive strengths of recycled aggregate concretes at 7 and 30-days when compared with NA concrete ones (about 20 % at 7 and 30-days) can be seen in Figure 3. The lower values can be due to higher water/cement ratios in recycled concretes even though Barra (1998) stated that increases in strength corresponding to water/cement ratio decrease in recycled concretes were not proportional to increases evaluated for conventional concretes.

In addition, comparing the compressive strengths for RCA1 and RCA2 concretes, it can be noted that the original concrete compressive strength has little effect on recycled aggregate concretes, since differences between RCA1 and RCA2 compressive strengths amounted to no more than 1.5 MPa for original concretes differences of 11 MPa.

Drying shrinkage tests were performed on cylindrical specimens (0.15 x 0.30 m), which after mould release were stored in an air-conditioned room at 20 °C and with a relative humidity of 50 %. There were two specimens for each concrete type. The strains were measured through electrical strain gauges (30 mm length) glued in the cylinder surface. Figure 4 shows the shrinkage strain evolution with time from 3 to 28 days.

The 28-day shrinkage strain of RCA concretes was found to be higher than of NA concrete (45 % in RCA1 and 84 % in RCA2) (Figure 4). The higher porosity and consequently lower specific density of RCA increase the aggregate deformability and decrease the restraint capacity of deformation of the cement paste. Despite the higher water/cement ratio in recycled aggregate concretes, it is supposed that the aggregate properties were paramount to the highest values of shrinkage strain. Furthermore, the higher shrinkage strains of RCA2 concrete when compared with those of RCA1 concrete (about 35 %) indicate that the mixing proportions and strengths of original concrete can modify the drying shrinkage of concretes produced with coarse recycled concrete aggregates.

The Modulus of elasticity was evaluated according to LNEC E 397 using cylindrical specimens. A mean value of 32 GPa was obtained for NA concrete at 32-days compared with 26.2 GPa for RCA1 concrete and 24 GPa for RCA2 concrete. The lower values in recycled concretes (22 %, 33 %) are, as for shrinkage, due to the higher deformability of the whole coarse aggregate and cement paste.

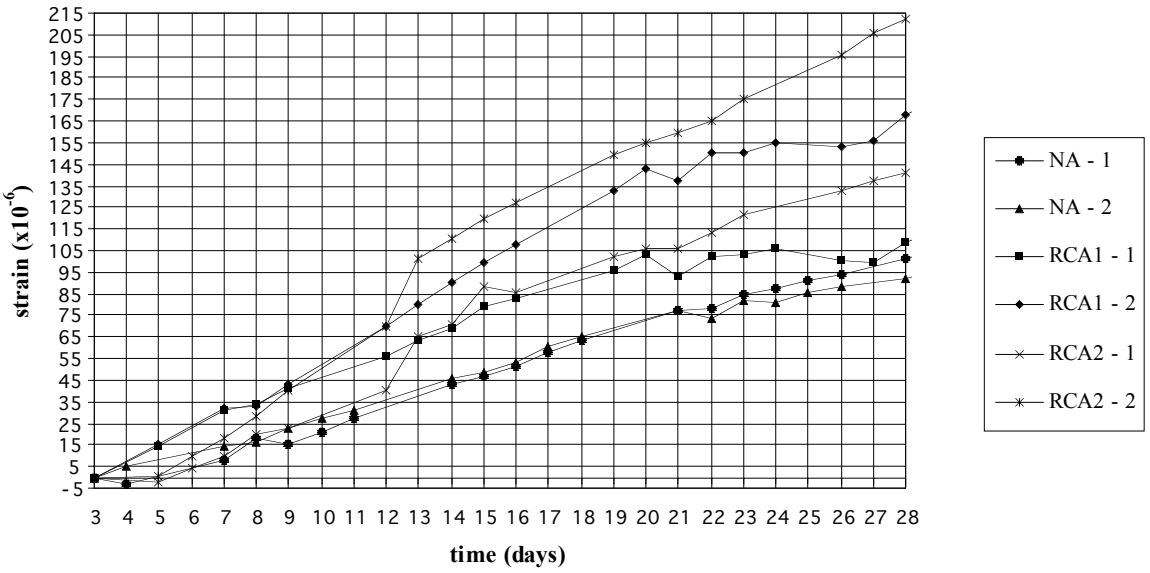

Figure 4 Shrinkage strain evolution with time

5. GENERAL CONCLUSIONS

Tests using coarse RCA produced from two original concretes with different compositions and compressive strengths showed that the compressive strength of RCA concretes does not depend on the compressive strength of original concretes. Regarding properties related with deformability (dry shrinkage and Modulus of elasticity), differences in RCA properties caused by original concrete characteristics can modify the performance of RCA concretes.

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Citizen Environmental Commitment towards Car Use Reduction: case study

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1. INTRODUCTION

Environmental problems in metropolitan areas do not arise just from production and consumption; they also come from traffic, which is being taking into account as an important issue of the environment by some governments. Private cars are probably the most important factor of the environmental impact caused by individual consumption. The consumption of fuels (gasoline and gas-oil) for private car is currently an amount of 11 Mtep, which makes up for approximately 14% of the total energy consumption in Spain. According to data offered by the IDAE (Institute for Diversification and Energy Efficiency), there will be a progressive reduction of the total fuel consumption, for private transport in the year 2005. The consumption of leaded gasoline is also falling off drastically and is being replaced by unleaded gasoline. The consumption of gas-oil is also decreasing. Besides, manufactures pushed by directives offer promising significant reductions of the gas emissions per kilometre for the next years. As well, the IDAE highlights that the energy consumption by using private car accounts for about the half of the domestic energy consumption. Although traffic can be considered one of the main sources of pollution in cities, some progress has been made with more efficient engines, such as catalytic converters and lead-free petrol, which means individual cars may be less polluting. However, the car numbers and use are growing so that the overall pollution continues to increase. On the other hand, the environmental costs in terms of carbon dioxide production, pollution, congestion, noise and disturbance to communities along busy roads has resulted in some local government to redirect investment towards public transport.

This research studies the citizen commitment with the environment focusing in the effort of reducing car use. The method used consists of a given questionnaire to the neighbourhood of the existing urbanization named Las Huertas. As a first step of this research, the Majadahonda community principles have been described. Next, the measures taken by the local government to improve the public transport in the town, as well as the larger public transportation network to Madrid city and to closer towns built by The Community of Madrid government have been analysed. Finally, the results of the questionnaires have been studied.

2. MAJADAHONDA' COMMUNITY AND TRAFFIC PLANNING

In 1960 Majadahonda, situated to the northwest of Madrid city, was a small town of 3044 people spread out along a traditional high street with several bars, a market, shops, a bank and a church. In 1970 Metropolitan Area's Plan for Madrid identified the need to decentralise population to a series of small towns around the capital. One of these towns was Majadahonda, which due to its exceptionally good location, eighteen kilometres far away from the city centre, began to be developed as privileged area for middle-class people changing the surroundings of the town into attractive urbanizations with plenty of gardens. At

the same time, employment, public schools, parks, sports centres, health services, music hall, shopping and leisure were provided by the local government, which still is planning to carry out other civic facilities as the building of a Hospital. In 1998 the planned population was increased to 42.000 inhabitants (70.000 inhabitants are estimated for the year 2016) and the traffic was seen as much of a problem. Nowadays, the population is 56.000 inhabitants.

The two General Plans of Urbanism of Majadahonda (1974 and 1984) were focused on creating an urban community, which is spread on circles around the town centre, with low density and a high life standard. A series of principles were established for the new development, the vision was of a quiet centre where the people had several options to use such as: leisure (restaurants, cafés, theatre, auditorium), shopping (small shops) and other services (bank, market, supermarket, Town Hall, foreign language schools, etc). Besides, since the ratio of young people is very high, most of the leisure development (dancing, cinema, ice-skating, etc) and big shopping centres were concentrated in a no residential area, on the edge of the centre. The key element to this was traffic management and the new town plan stated: In order to reduce the car parking within the town centre, any new residential and office buildings should built parking on the building basement for its residents. To create a town centre more friendly for citizens, the town high street was pedestrianised and a subway car parking (four hundred cars capacity) was built with several ways out to the high street, which became a great success almost immediately, since the people can enjoy getting together on a bar-terrace, walking, etc. Besides, the car parking within the town centre was regulated through the ORA, which means payment for the parking period of time, although town centre residents do not have to pay for parking. The speed was limited to twenty kilometres per hour in the town. In order to achieve a more fluent traffic on the main streets, rotundas and raised pedestrian crossing have been built recently, instead of the traffic lights. On the other hand, all the large commercial and entertainment centres situated outside the town centre have their own car parking areas where cars and delivery vehicles have a direct service approach to every building. Access for pedestrian from car parks to the buildings is direct and safe.

3. IMPROVING PUBLIC TRANSIT

The three main components of improved public transit are related to the three categories discussed below.

3.1 Urban public transport

Majadahonda has an extension of 38 square kilometres, which means that not all the urbanizations are within a walking distance to the town centre. None effective alternatives to car use for circulating within town have been taken by local authorities. Since there is only one circular bus service, the people must to use the inter-city buses, which leads to decrease the efficiency of these buses. As a result of the opposite party pressure, the local authority has signed an agreement with The Association of Transportation to increase the urban bus lines; so next year will be four bus lines. The frequency will be the same as nowadays, from Monday to Friday is 45 minutes and on weekend is 75 minutes.

3.2 Road networks

The road networks among Majadahonda, the neighbouring towns and Madrid downtown are M-515, M-516 and M-503 roads which are linked to the Eje-Pinar highway, and M-509 road which is linked to the N-VI highway, which is one of main highways in Spain. Both highways are also connected by M-30 highway. In order to reduce congestion and enabling people to save time and money in their commute to work, the Community of Madrid has built a lane in the N-VI highway, called BUS-VAO. Only buses and cars with more than one person are

allowed to circulate through the BUS-VAO lane. This lane has five exits and entrances to the closer towns (Majadahonda has two different exits from Madrid). The operation modes are: direction Madrid from six till eleven in the morning, and opposite direction from four in the afternoon till nine at night. The rest of the time is closed. The buses from each town, once they get in the BUS-VAO, go directly with no stop to the Commuter Bus Station in Madrid city, where is also located the underground station. This Station allows people mobility towards different directions. Besides, the Station provides different services as banks, cafeteria, and shops.

3.3 Inter-city public transport.

The connection services between Majadahonda and Madrid are as the following:

a) City-bus service: There are eight different bus lines running from six in the morning till noon. Only the 651 buses have a frequency of five minutes during all day running from Monday to Friday. The 652 buses have a frequency of 20 minutes, and the rest has a frequency of 30 minutes. There is also an express bus line running from six till nine thirty in the morning. The express bus stop is located in the town centre; these buses go directly to the BUS-VAO lane. The period of time to get Madrid from Majadahonda by normal bus service is in the range of ten-twenty minutes depending on the stop you catch the bus, these bus lines must cover its route before getting in the BUS-VAO lane. So, it takes you twice the time than express bus service. The monthly passes cost 55Euro for youngster and 70 Euro for normal people; yearly passes are also available.

b) Rail system: There is a suburban train station two kilometres far from the town centre. The frequency is of fifteen minutes. The train runs from 6 till noon. Next to the rail station there is multi-storey car parking. For people with monthly passes, the price is 1 Euro the first fourteen hours. The regular price is 1,5 Euro per hour, 10 Euro per day and 60 Euro per month.

The connection bus service between Majadahonda and the neighbouring towns is not as good as expected. There are five town-bus lines. The schedule and frequency are variable. There is not Commuter Bus Station and the bus lines schedules are not connected each other, so if you have to change, probably you would spend more than an hour waiting in the bus stop. Fortunately, some towns are also connected each other by train service, which enable people to save time.

4. RESULTS AND DISCUSSION

The method used in this study consists of given questionnaires to the neighbouring of an existent urbanization called Las Huertas. Questions were classified into four general areas: A) Personal preferences relating to transport. B) Neighbouring opinion on public transport. C) Personal commitment with the environment. D) Neighbouring opinion on local government environmental policy. Only residents of eighteen years old and older were invited to answer the given questionnaire.

Las Huertas was built in 1972, by that time Majadahonda was a town of about 6000 inhabitants. The urbanization is located within a walking distance of 15 minutes to the town centre. This urbanization is faced to four different streets and provides car parking in the block basements for all residents; each garage has a way out to the street. Several city bus stops are next to the urbanization. Most of the household compositions are families (73,3%), some are divorcees with children (5,6%), 11,1% is pensioners and 10% are widows. The neighbouring is mostly middle-class. There is an average of 1,7 cars per household.

4.1 Personal preferences relating to transportation.

In this section of the given questionnaire, the neighbouring were asked to indicate their personal preferences relating to transportation among the following: A) Public transport rather than car. B) Driving the care more economical. C) Trying to fill the car for all journeys. D) Only family car. E) Sharing-car. The residents were invited to reduce car use one weekday per week, it was called "sustainable day".

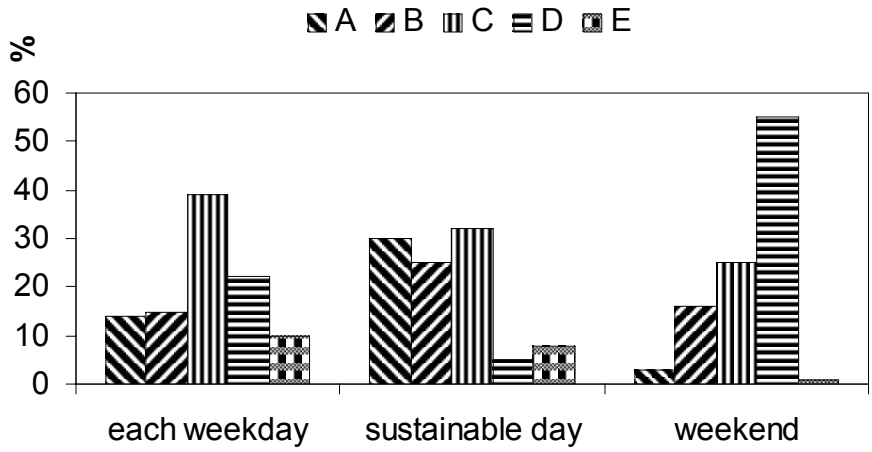

Figure 1. Personal preferences of the neighbouring relating to transportation

The results shown in figure 1 indicate that the majority of neighbouring chose car as transportation way, although differences in the neighbouring' preferences relying on type of journey can be observed. For each weekday, only 14% of the neighbouring selected public transport (A option). Trying to fill the car for all journeys (C) was the most selected option, approximately 39%. However, sharing-car (E) was chose only by 10%, although both allow cars to go through BUS-VAO lane. Relating to the type of car, about 22% of the neighbouring chose the family car (D), and about 15% the economical car (B). As expected, for the weekend about 55% of the residents selected the family car (D). Driving the economical car (B) and trying to fill the car for all journeys (C) were also selected. The public transport (A) and sharing-car (E) were scarcely chosen. It is interesting to highlight that, for the sustainable day, approximately 30% of the residents chose the public transport (A), although still the majority of the neighbouring preferred car as transportation way. Driving the economical car (B) and trying to fill the car for all journeys (C) show almost similar results than using the public transport. This attitude from neighbouring can be considered as an environmental commitment, since the family car option (D) decreased. The sharing-car (E) shows similar results that the obtained on each weekday, probably because this option means a commitment between neighbouring, which could be some time hard to keep up.

4.2 Neighbouring opinion on public transport services.

In this section of the given questionnaire, the neighbouring was asked to say if the public transport services have the following characteristic: easily access, good frequency and good connection service, fast, clean and comfortable. Only neighbouring, which have used public transport at least once, should answer this section.

As it can be seen from figure 2, city-bus transportation (C) shows greater approval than other public transports mainly due to its easy access to bus stop from the urbanization, as well its

good location once the Commuter Bus Station has been reached. The train (B) and express bus (D), in spite of their good connection service, they have much less popularity among neighbouring mainly because of their bad access possibilities, the train station is about three kilometres far away from the urbanization, and the express bus stop is in the town centre. The urban bus (A) and inter-town bus (E) show the lowest approval

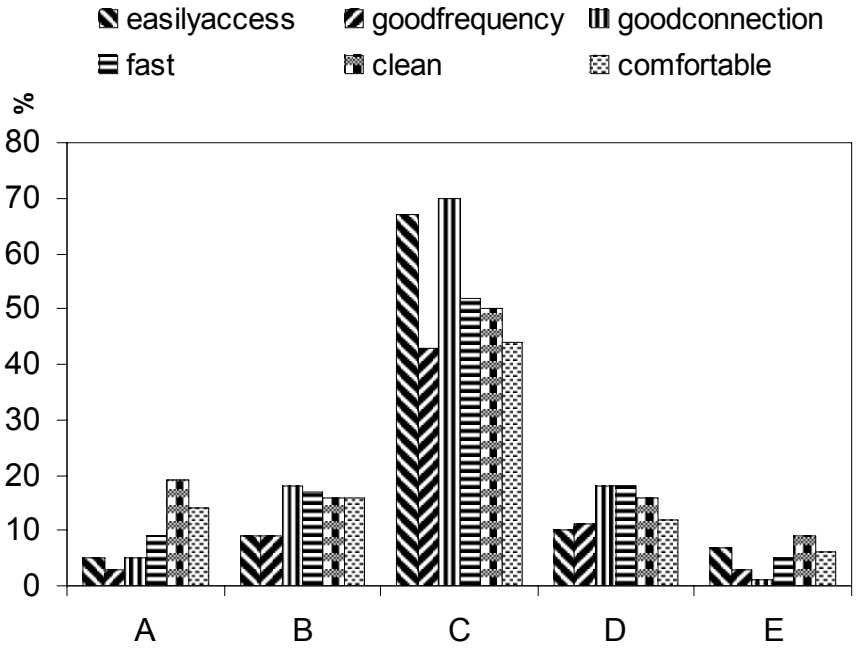

Figure 2. The opinion of neighbouring concerning public transport services

4.3 Personal commitment with the environment.

In this section of the given questionnaire, the residents were asked to say their personal commitment with the environment, in relation to the following issues: A) Selling the car. B) Riding bicycle to work / university and C) only using public transport. D) Trying to fill the car all journeys each day. The results indicated that, the neighbouring does not agree at all with either selling the car or riding bicycle to work/university, since no residents selected these options. Besides only approximately 3% chose only public transport, although about 25% of the residents chose trying to fill the car for all journeys each day.

4.4 Neighbouring opinion concerning the environmental police of local government.

In this section of the given questionnaire, the residents were asked to answer the following questions: A) Agreement with the environmental police. B) More environmental commitment is needed. C) More investment in public transport is needed. The results indicated that, only about 7% of the neighbouring agreed with the environmental police of the local government (A). Approximately 27% think more commitment is needed (B) and about 66% answered that more investment in public transport is needed(C).

In general, the given questionnaire showed how neighbouring made choices regarding car use over the public transport. About half of neighbouring chose driving no single occupancy vehicles each weekday, and they did not agree with both selling the car and riding bicycle all journeys but, most of the them chose public transport and driving no single occupancy vehicles in a sustainable day. On the other hand, most of the neighbouring though that the

public transport service has a deficient operational mode with the exception of the city-bus. The neighbouring thought that more local government environmental commitment and mainly more investment in public transport are needed.

6.CONCLUSIONS

These findings indicate a need for a change in local government environmental police and people behaviour concerning to car use.

The paper conclusions are the following: 1) the BUS-VAO lane in N-VI highway can be a particularly effective alternative to single occupancy driving since they enable people to save both time and money in their commute to work/university. 2) The combination of easily access, good frequency and good connection service seems to be the most important operational improvement that public transport must achieve in order to attract more users. 3) Improvements in urban bus lines are needed in order to induce neighbourhood to forgo car driving in town. 4) Most of the neighbouring though that more investment in public transport is needed.

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8. ACKNOWLEDGEMENTS

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Sustainability of Corrugated Cardboard Houses as Temporary Emergency Shelters

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1. INTRODUCTION

Background: The situation concerning disasters in Japan (earthquakes and typhoons). Japan is an earthquake-prone country, and is stricken by large earthquakes every several years. Furthermore, typhoons assault Japan every year. As a result of earthquakes and typhoons, many homes are damaged, creating a need for shelters. Many people take temporary refuge in public facilities such as schools, in tents, etc. Although the duration of such temporary shelter living may not be long, it is difficult to ensure a minimal living environment because of a lack of privacy, no soundproofing, difficulty in securing one's own belongings, and a lack of insulation against the summer's heat and the winter's cold.

Until their own homes can be rebuilt, many people are forced to live in temporary housing built by public institutions, such as prefabricated homes, etc. Also the amenities of life are inadequate in such places. Because such temporary housing in constructed in bulk, within a limited space, if living there is prolonged, contact with one's own community can become attenuated. Moreover, such temporary housing cannot undergo repeated usage, so problems can arise in terms of the conservation of resources.

Proposal for temporary emergency shelters using corrugated cardboard. In light of the situation described above, the author proposes temporary emergency housing, using corrugated cardboard panels, to be used for several months, from the time a disaster occurs until new permanent living quarters can be decided upon. In other words, in order to minimize the length of living in inferior shelters such as tents, public facilities, etc. until permanent housing is available, the disaster victims themselves can set up temporary shelter facilities in the area where they previously lived or nearby, thereby securing their own living space. The main material for such temporary emergency housing is recyclable corrugated cardboard. Such housing is environment-friendly because it can be recycled following use.

2. OVERVIEW OF TEMPORARY EMERGENCY HOUSES USING CORRUGATED CARDBOARD

These newly-developed corrugated cardboard houses are no different from others using multi-layered corrugated cardboard panels (about 10 cm in thickness); but several ingenious devices have been adopted concerning the way in which the panels are assembled and joined to each other.

Wood-framed type: This is a beginning stage type, with corrugated cardboard layered crosswise, having plasterboard on both sides, with the surface panel being coated with polyester resin. In order to ensure the evenness of stress transfer among panels, all four sides are enclosed in a wooden frame (Figure 1). The plasterboard can easily be separated from the wood frame; and the corrugated cardboard is made 95% from old newspapers. Because water-soluble adhesive agents are used, the paneled portion can be re-used following initial usage. A in-plane shearing test, a simple bending test to seek if they break, and an insulation test are being performed on the panels. Although its strength is considered fully adequate for temporary housing, because screws are used at the joints the method of construction cannot be considered first-rate *1.

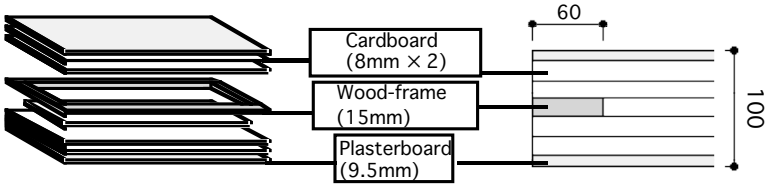


Figure 1. Corrugated Cardboard of Wood-frame Type

Current proposal: The current proposal involves a further simplification of the wood-framed type. As indicated in Figure 2, tongue and groove joints are configured in the corrugated cardboard itself, thereby simplifying their joining (Figure 3). Figure 4 shows an overview of experimental 13.2m^2 temporary housing using a multi-layered cardboard panel system. This experimental housing is a living room only, not yet equipped with a kitchen or bathroom. Corrugated cardboard layered panels are spray-coated with urethane resin mixed with a combustion-resistant agent. Thus, waterproofing and fire retardation are ensured. During these experiments, the wall panels are not sprayed with urethane, but rather covered with a waterproofing "sheet" as a substitute.

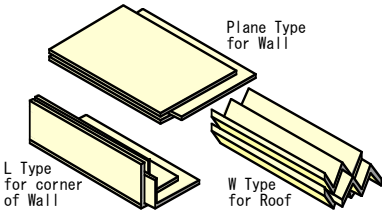


Figure 2. Polyurethane Coated Cardboard Panel

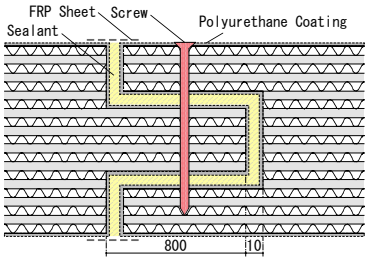


Figure 3. The Tongue and Groove Joint of Panels

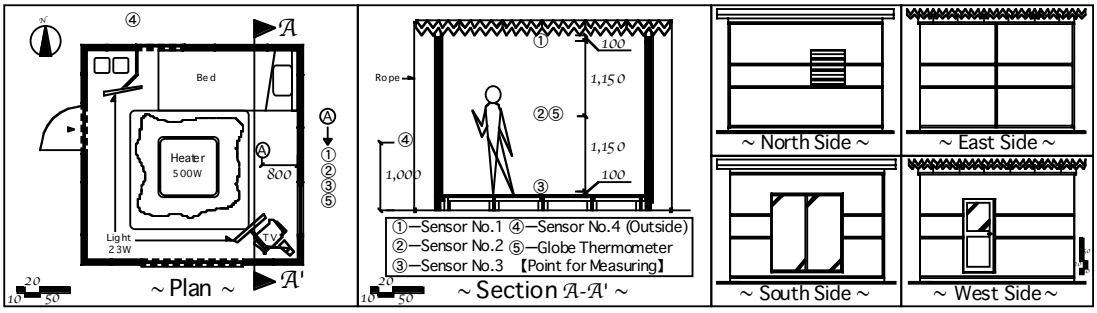


Figure 4. Outline of Corrugated Cardboard House and Point for Measuring

3. THE QUALITY OF CORRUGATED CARDBOARD TEMPORARY EMERGENCY HOUSING

a) Structural safety

Simple bending testing and in-plane shearing testing were conducted on the strength of each panel to be used for experimental housing. Table 1, Table 2 shows the results.

Table 1. Simple Bending Testing

Test Piece	Size(mm)	Average Mass(kg)	Average Maximum Load(kN)	Average Bending Load(N/cm²)	Average Breaking Load(kN/m²)
FWS21-0	450×900×105	4.49	3.03	32.1	9.62
FWS21-1.64		6.37	8.22	86.9	26.1
FWS21-1.99		6.79	7.99	84.5	25.4
A-19-O('99)	450×900×100	4.39	2.66	31.0	8.43
F7||-1.97	600×900×35	4.53	6.13	438	14.6
F7=-1.92		4.47	2.93	210	6.98
F7#-1.96		4.44	3.75	269	8.92
W7=-1.95		4.56	19.2	107	91.4

Table 2. In-plane Shearing Testing

Test Piece	Size(mm)	Average Mass(kg)	Average Proportional Limit(kN)	Average Maximum Load(kN)
FW21-0	900×1800×105	17.6	1.39	2.47
FW21-1.65		24.6	1.65	2.78
FW21-3.07		30.4	1.44	3.78
A-19-O('99)	900×1800×100	27.5	1.00	2.53

Test Piece Name
FWS, F, FW: Plane Type / W: W Type
00: Layer – 00: Coating (mm) / ||, =, #: Layer Direction

b) Constructibility

Figure 5 illustrates the process by which corrugated cardboard temporary emergency housing is constructed. With a view to removing the housing following the experiments, the foundation was not joined with the ground. A rope was tied around the overall structure and affixed to the concrete surface on which the house rested. Corrugated cardboard layered panels were laid on top of the foundation as a floor to which laminated boards (12mm in thickness) were secured by hardware. The waterproofing sheets on the wall panels were spray glued. The objective was to carry out the entire construction process by two adults. However, the weight of the roof panels was so great that four people were required for assembly. Caulking was performed at the panels' joints and around the fixtures. The entire process, including the interior and exterior, required five days. This experiment demonstrated that if the building material for temporary emergency housing can be obtained, disaster victims having the assistance of some neighbors can within several days easily construct temporary housing themselves, on their own property.

Figure 5. The Construction Process of the Corrugated Cardboard House



① Foundation ② Wall Panels ③ Roof ④ Facing

c) Livability

In anticipation of the question of livability while taking refuge, the environmental quality of the room was measured. ①~⑤ in Figure 4 indicate the locations that were calibrated. The temperature, humidity, and "globe" temperature, were measured in order to determine the average level of comfort (PMV) and the anticipated level of dissatisfaction (PPD). The duration of the testing was from November 22 through December 6, 2001, with people actually staying in this experimental dwelling. The number of people who were in the room and the events that took place were recorded.

Figure 6 shows a portion of the actual calibration results, pertaining to room environment quality (November 22, 2001). The ambient temperature began to rise in the morning along with the rise of the sun, as did the temperature of the room. The temperature declined gradually during the

afternoon, with 1:00 PM being the peak. The PMV and PPD showed somewhat low values from late at night until the morning; but they reached near zero during the day, indicating a comfortable environment.

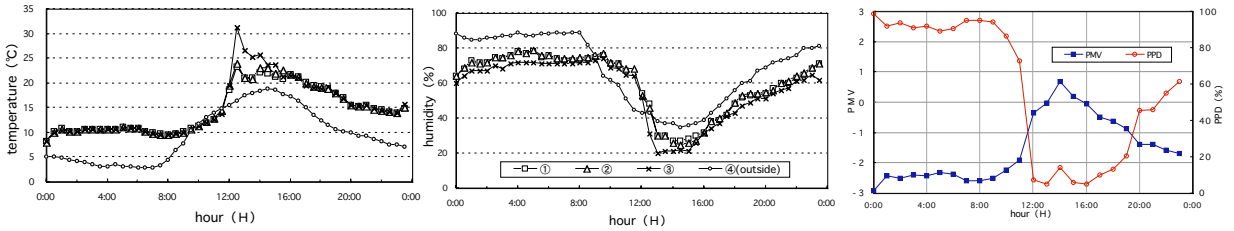
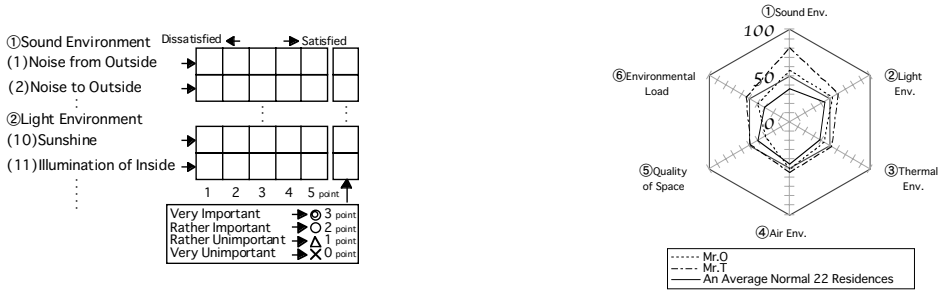


Figure 6. Changes with the Passage of Time of Temperature & Humidity & PMV & PPD

In order to provide a comprehensive evaluation of the room environment within the experimental dwelling, POEM-H (Post-Occupancy Evaluation Method of Houses) was used.

Figure 7 (a) illustrates the comprehensive question and answer survey (sound, light, heat, air, space, and environmental load) that was conducted, and the balances for each item. At this time, the temporary emergency housing using corrugated cardboard was compared in terms of mean values with 22 ordinary homes. The check marks in each item were counted, following which the levels of satisfaction and levels of importance were assigned numerical values. Figure 7 (b) shows the environmental evaluation results obtained following residence therein (In the case of the experimental housing, two persons provided the evaluation). Following comparison with the results from the other homes, it became clear that the residential environment in the experimental



housing was the same as for that in the ordinary homes.

(a) A Parts of Questionnaire **(b) Chart Graph of Indoor Environment (Env.)**

Figure 7. A Finding of residential Environment

4. LIFE CYCLE EVALUATION FOR TEMPORARY EMERGENCY HOUSING

Materials used: Corrugated cardboard : 1436 m^2/13.2m^2 (in the case of the experimental housing at this time.) Japan's corrugated cardboard production volume is 13, 217 (million m^2); and that of the world is 124,873 (million m^2), approximately 10.6% of which is produced in Japan, the second largest amount next to the United States' production of 30.2%. The recovery ratio for corrugated cardboard in Japan is was 84.4% in 1997, 85.9% in 1998, 88.8% in 1999, and 93.4% in 2000, demonstrating a steady increase. In addition to the above, urethane paint, waterproofing paper, aluminum sashes and aluminum doors are used. Table 3 illustrates the comparison with temporary shelter facilities and temporary housing involving the use of other building systems. The environment-friendly characteristics of corrugated cardboard housing are noteworthy .

5. CONCLUSION

・By making corrugated cardboard panels and by simplifying the tongue and groove joints, it has become possible to build emergency temporary housing having high levels of constructibility and livability and of adequate strength.
・It has become clear that the room environment for temporary emergency housing using corrugated cardboard is virtually the same as that for a comparable room in ordinary housing.
・Comprehensively speaking, temporary emergency housing using corrugated cardboard can be evaluated as being environment-friendly compared to other forms of temporary housing.

6. ISSUES TO BE FACED IN THE FUTURE

Although at this time waterproofing was carried out using a urethane coating together with waterproofing sheets, there exists the possibility of pinholing during the coating process. In the case of the waterproofing sheets used this time, there may be a problem in terms of durability. These are points requiring further review.

Table 3. LCA of Temporary Shelters

	Corrugated Cardboard House	Tent	Prefabricated temporary house
Deforestation, Exploitation	Raw materials for coating, plywood, aluminum, waterproof sheet and sealant. ○	Raw materials for cloth, metal poles and rope. ○	Raw materials for steel, insulation, plywood, aluminum, waterproof sheet and sealant. △
Production	Corrugated cardboard, coating, aluminum sash, waterproof sheet, sealant and plywood. ○	Cloth for tent, metal pole and rope. ○	Steel frame, plywood, metal sheet for facing and sash. △
Construction	Small-sized electric tool and manpower. ◎	Manpower. ◎	Construction machinery. △
Use	Small-sized heater (for winter). ◎	Lack of privacy, thermal and sound insulation, Heater (for winter). ×	Performance of minimum dwelling conditions. ○
Maintenance	Repairing for waterproof and so on. ○	Repairing of frayed spots. ○	Nothing for several months. ○
Disassembly, Demolition	Manpower. ◎	Manpower. ◎	Construction machinery. △
Withdrawal	Easy. ○	Easy. ○	Easy for reuse, Trouble to sorting. △
Reuse, Recycle	Recycle of sash and corrugated cardboard (except coating layer) are possible to recycle. ◎	Difficult to reuse except metal poles in the case of a long term use. ○	Reuse is possible in the of a short term use. △
Scrapping	Coating, sealant. ○	Cloth. ○	Many kinds, large quantity. △
Storage, Transport	Bulky but light in weight. ○	Compact and light in weight. ◎	Bulky and heavy. △

◎:very good, ○:good, △: not so good, ×:bat

Development of the Nissen hut (vault) type: At present, vault-type temporary emergency housing is under development in order to deal with the problem of local stress at the tongue and groove joints by reducing the number of such joints. Currently, strength experimentation using a half-size scale model has been completed (Figure 8).

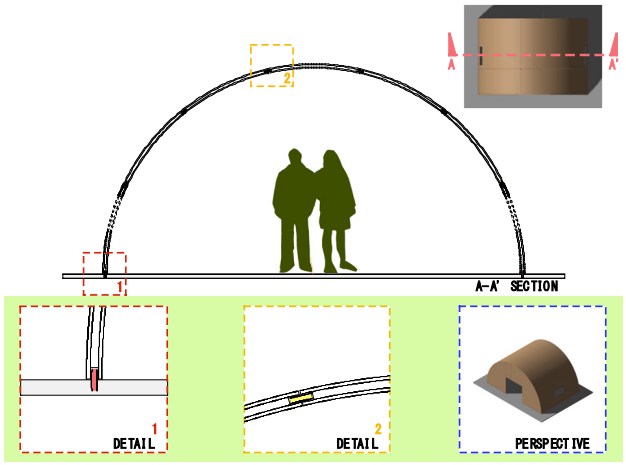


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Figure 8. A Proposal for the Corrugated Cardboard House of Nissen hut Type

Performance Indicators for Green Residential Buildings Constructed In New York's Battery Park City

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ABSTRACT
This paper reports on efforts to describe how the "green" high rise buildings--which are privately developed on sites administered by the Hugh L. Carey Battery Park City Authority in New York--will perform across a set of environmental parameters over a period of at least five to eight years.

INTRODUCTION
Approximately 9000 people now reside in various high-rise buildings in Battery Park City (BPC), New York. Recently, the Battery Park City Authority instituted a set of *Residential Environmental Guidelines* intended to guide the level of environmental performance of new buildings built within BPC. The building guidelines seek to increase energy efficiency, enhance indoor environmental quality, conserve materials, resources, and water, and in sum contribute to occupants' quality-of-life. Construction of the first building designed under those guidelines has begun. Two other similar buildings are also in the process of being developed. All buildings, each with over 300,000 square feet and containing approximately 300 units, will exhibit new standards of best practices. At this time, no new planned urban development of eight high-rise buildings housing approximately 8,000 people in 2,000 or more apartments, and adhering to such levels of environmental performance, is known to exist anywhere in the United States. These buildings will significantly increase the BPC building stock, double the BPC population, and provide an unparalleled opportunity to begin performance studies of environmentally proactive building practices.

There are a number of green guideline programs that have produced a growing number of functioning green buildings in the United States. Paralleling these developments is a growing need for credible information. Yet, there is little publicly available data to inform the profession. The intent of the discussion that follows is to describe the early stages of a BPC program capable of answering some of those questions. Such a program would represent important first steps in contributing to the state-of-the-art of high performance residential building.

Defining which performance indicators would best serve the purposes of building documentation requires an assessment of methodology, instrumentation, observation techniques, and analysis which can be reasonably quantified and cost effective over time. Given the nature of private development there is also the need to strike a balance between building integrated data

acquisition and other more indirect non intrusive methods of observation. The outcome of balancing these needs is a provisional three tiered strategy defining a number of building performance indicators which rely on 1) remote building observation 2) proximal building observation, and 3) direct building integrated monitoring.

Construction of the first residential building at 20 River Terrace (hereafter, 20RT) is more than a year away from completion and occupancy. What follows is a report on some performance indicators that have been determined to be feasible for observing select portions of the building's functioning over time.

REMOTE BUILDING SENSING & SIMULATION

Attempts to "picture" what 20RT would look like from the perspective of different but very general points of view initiated a ranging interest in seeking to observe the building from the distance of a satellite thermal image to the conceptual space of establishing relationships between greenhouse warming, energy and building materials.

High altitude infrared images. Satellite images taken at selected times during summer months of 20RT in the context of the surrounding buildings in lower Manhattan are expected to make the heat island reducing strategies employed on the building visually and quantitatively evident. Those strategies include an aggressive rooftop planting program that includes bamboo and indigenous grasses. Other unplanted areas are to be covered with high albedo materials.

Material inventory and embodied energy. Significant portions of the building materials used in 20RT are intended to contain recycled contents. Typical arguments for this strategy are the reduction of waste to landfill or, in other instances, the conservation of nonrenewable resources. Material inventories will describe the quantities of sustainable material, rapidly renewable materials, recycled content materials, and non-renewable materials that have been used. The same inventories will provide the basic information for estimating the energy embodied in those materials and assessing sustainable gains where possible.

Aggregated energy use and greenhouse gas reduction estimate reductions. Computer simulations of 20RT using DOE 2.1 were an integral part of the building's design. At this point in time there are estimates of subsystem and total building energy use. It is expected that once the building is in operation with it complement of tenants, annual metered energy data will become available for study. First, this data will be compared with the DOE 2.1 simulation to establish the degree of reliability of the simulation. Second, compared to a base case building, energy efficiencies will be noted, and importantly, greenhouse gas reduction estimates will be calculated.

PROXIMAL SENSING AND OBSERVATION.

There is a need to understand how well the design strategies employed in creating the building's shell contributes to energy efficiency and indoor environmental quality. Because of constraints imposed by three hundred occupied rental apartments, there is also a need to explore what observations can be effectively made from the building's exterior.

Building enclosure. The building's skeleton is composed of reinforced 7" concrete floor slabs bearing on reinforced columns. The exterior façade, is of a brick veneer insulated CMU cavity wall construction covering approximately 50% of the building's surface. In an attempt to optimize daylight penetration of interior spaces, double paned low-e glass (ViraconVE1-2M) are utilized on 39% of the remaining wall area. Significantly, insulated aluminum window frames occupy remaining 11% of the wall area. All operable windows are casement units selected because of their resistance to infiltration when closed. The building has two major roofed areas containing the external elements of mechanical systems, water tower, and exhaust vent stacks. All roof areas utilize a roof planting program and the use of high albedo materials to reduce heat island affect. The planted insulating roof membrane system and special detailing at parapet walls contributes significantly to building insulation.

Seasonal thermal imaging is the technique expected to be used to record the building's façade temperature patterns and observe for breaks in the integrity of the façade, particularly at and around the window areas. The same technique is expected to determine the temperature at window surfaces from which indoor temperatures might be inferred leading to some understanding of differences in internal thermal levels.

On site weather and air quality station. Most assumptions regarding the impact of the ambient environment on the design and performance of the 20RT come from weather bureau records and may come, in the future, from background data associated with indoor air quality surveys. The location of 20RT, its height, planted roof strategy, and major exposure to the Hudson River prompted many questions about climate events as they occur at and around the building. To answer some of these questions a roof top micro weather station will be installed to provide records of temperature, wind speed and direction, rainfall, and relative humidity. Additionally, air temperature, and relative humidity monitoring are a part of the building's air management system. Still there are further air quality observations considered to be of interest, particularly to the performance of the building's air filtering system. Thus, a program for on site samples of pollen, mold, and particulate matter ($PM_{2.5-10}$) will also be established.

Monitoring planted roof areas. Using planting to cover a portion of the building's two roof areas is required by the BPC guidelines. Presently there is an aggressive planting scheme utilizing bamboo, shrubs and grasses that are hardy enough to withstand the anticipated roof-top microclimate. The intent of planted roofs represents a strategy to reduce building-heat island affect. There are also the benefits to tenants of the planted space as a building amenity. High rise rooftop microclimates may be thought of as similar to some mountain top environments, but they may function quite differently as an environment to reduce heat island affects. The long term monitoring of wind speed, temperature, and relative humidity will be accomplished by the micro weather station. Yet there is great interest in empirically observing the temperature gradient that is established at the planted surface, and at one and two feet above the surface. These observations would be the result of equipment added to the micro weather station.

DIRECT MONITORING AND OBSERVATION: ENERGY, IAQ, AND WATER

From an energy point of view the 20RT could be envisioned as an assembly of independently functioning mini-environments where three sets of variables dominate the major requirements

for building energy demand and the potential for energy efficiency. The building could be also conceptualized as an envelope that under different wind and weather conditions is constantly undergoing changes in positive or negative skin pressure at different building sides and levels. At the same time, there is another set of counteracting internal building pressures that are created by the building's functional divisions, material composition, and air handling systems. In effect, the building is much like a self sealing inner tube attempting to achieve equilibrium while under the constant impact of pressure differences and air penetrations from both outside and inside its skin. Therefore, regardless of an apartment's orientation or elevation, opening a window in one of the building's apartments will alter the pressurization dynamics of that apartment and, to some extent, other adjacent interior areas. Under these conditions, many steady state assumptions regarding energy efficiencies and indoor environmental quality may always be in need of qualification.

Building enclosure. Although of great empirical interest, no system of observation inside or outside the building for stack effect, pressure differentials, infiltration, and etc., is considered possible at this time. For that reason, although with a diminished range of investigation, external ("proximal") thermal imaging will be utilized to directly observe façade integrity through its radiant behavior.

Building management system and environmental controls. The building's environmental control systems provide for tenant requirements, amenities, conditioned air, and general comfort conditions. The equipment that delivers these conditions are integrated at the building's management system (BMS) where energy, functional monitoring, and data acquisition will be ongoing for the cooling tower, chiller/heater, combustion efficiency, hot & chilled water temperature and flow, pumps' energy use, and the main ventilation distribution system.

Tenant energy requirements. Energy use and efficiencies within apartments is partially in the hands of building management and partially in the hands of tenants. Therefore, tenant energy use deriving from the multiplicity of lighting needs, electric appliances, computers, home entertainment systems, offices at home, and the like, is the most difficult to assess. Each apartment will have centrally conditioned air provided by roof mounted gas fired chillers. The building provides central air that will be humidity controlled and filtered before delivery to each apartment. Further conditioning of apartment air will be done through room dedicated 4-pipe fan coil units controlled by programmable thermostats. Each apartment will have a gas range, refrigerator, dishwasher, and washer/dryer, and a sink garbage disposal. All installed electric appliances are U.S. EPA Energy Star rated. Apartments also have light dimming switches and a master control switch for a portion of apartment plug outlets. But, because of prior system design decisions, other than total apartment metering data, there is no capability to monitor tenant plug loads.

Indoor air quality. BPC guidelines require that at initial occupancy an apartment will exhibit no more than 50 ppb formaldehyde and 200 m^3 TVOC (above ambient air). It is expected that a five percent sample of apartment units selected for testing will fulfill the intent of the guideline. But, other variables of interest to be observed for in these units will be CO and $PM_{2.5\text{-}10}$. Particulate matter will be tracked at ambient levels at the supply air source, at central filters, and at an

apartment's supply diffuser. It is anticipated that outdoor-indoor air quality ratios will be established in conjunction with observations from the roof top micro weather station.

Air exchange rate. Apartments will have exhaust fans in kitchens and bathrooms removing air at a rate of 135 CFM and 35 CFM, respectively. The functioning of these exhaust systems is an important strategy to provide occupants with the benefits of positive indoor air quality and to the maintenance of a negative pressure differential between apartments and corridors. The CFM rate for the exhaust stacks will be selectively monitored.

Water conservation. Water conservation measures are an integral part of the BPC guidelines. Storm water at 20RT will be collected, treated and stored in a 10,000+ gallon holding tank for use in cooling towers or for landscape applications. Some reduction in storm water quantities will also be achieved through the extensive use of fully planted roof areas.

Black water treatment. Rather than use a gray water system, a significant design decision was made regarding the installation of a black-water treatment facility which would return treated water for toilet flushing. Such a building integrated system of sewage treatment is completely unique to New York City high rise apartment buildings and deserves some extended description.

Functionally, the black-water treatment system is a more efficient design response to the BPC guideline requirements than gray water utilization. Simply, the collection system needed to capture the gray water, treat it, and return it through separate piping was not cost effective in that it required additional resources and vertical building chase area. On the other hand, collecting all wastewater and directing it to a centralized treatment tank utilizes standard quantities of material and space, with additional plumbing needed only for the treated water being returned for toilet flushing.

The black wastewater treatment facility is sized to the amount of return water needed for toilet flushing, for cooling tower water make up, and for building related landscape irrigation. Typically, the wastewater treatment process occurs within a large metal tank. However, in the present application, the tank volume requirements are met through the design of a concrete holding tank integrated into the building's garage ramp. The wastewater treatment process has sequential steps that aerate influent, act as a trash trap, facilitate biological waste breakdown, filter water through ultra-filtration membranes, then disinfect the water with ultraviolet light, and finally, control water clarity through ozone oxidation. The integration of the black water system into the building's foundation fabric creates an unanticipated efficiency in space use.

There are water quality and health issues that need to be monitored and reported as a part of a permit process. An initial protocol of daily and then weekly water quality testing is a Department of Health requirement.

There is prior knowledge that the cost per gallon of treated water will be higher than the cost of New York City water. But, from this effort important questions regarding water conservation strategies could begin to be answered. First, there is the cost-of-treatment of an onsite mechanical water treatment system which needs description. The determinant of that value is the quantity and cost of energy and maintenance, per unit of water treated, and thus, a need for

monitoring those functions. Second, there is also the necessity for a more precise understanding of the costs required for closing the water recycling loop such that acceptable potable water is the end product. Both these questions, if answered, have importance to the possibility of urban high performance buildings becoming decidedly more resource efficient and self sustaining.

CONCLUSION

A reaonable number of LEED rated buildings are functioning across the United States, but the rating is a one time evaluation and produces no performance data. The recently instituted New York State Green Building Tax Credit, if approved for a building, requires an annual reassessment of select building functions for five years, but has no mandate to publish the performance data it acquires. In New York State significant pre-construction performance data is provided to a building design team by DOE 2.1 simulations supported in part by grants from the New York State Energy Research Development Authority. Some important contributions are being made with reference to smaller scaled residential projects in Canada and Scandinavia. Simply, there is little performance data available to inform the profession about the application and functioning of environmental strategies in thirty-storey high rise residential buildings.

Environmental building guidelines are good tools for establishing performance benchmarks and new learning, but without performance data to follow, the guidelines will contribute little to real progress. The BPC performance indicator initiative is in the first stages of development with its direction set by strategies drawn at this point in time. With eight residential buildings to be constructed under its guidelines continued efforts will be required to find the balance points between cost effective building integrated monitoring techniques, and other non intrusive methods of observation and measurement.

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The regulatory framework for sustainable development in the Australian construction industry

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1. INTRODUCTION

Major international environmental initiatives combined with the growing scientific evidence of environmental decline have spurred most countries including Australia towards a range of proactive initiatives, strategies controls and laws. This paper will explore environmental strategies and controls for achieving sustainability of the Australian construction industry. The paper will: (i) review Australia's environmental strategies (ii) map out its regulatory framework in the area of sustainable development/construction and (iii) explore the merit of voluntary environmental codes in the construction industry.

The internationally driven initiatives and strategies for achieving sustainable development combined with growing scientific and visible evidence of serious environmental problems such as global warming, ozone depletion and the depletion of non-renewable resources, have played a major role in awakening most countries from the years of environmental complacency and vandalism caused by ignorance and self-interest. In Australia, they have triggered a serious re-think of attitudes and policies resulting in genuine attempts to achieve sustainable development through new strategies, controls and laws.

Australia employs a three-tier system of government: federal, state and local. The federal and state governments have legislative power and can enact their respective environmental legislation. Local governments are mainly responsible for implementing specific state environmental legislations but may also impose their own local regulations. In this context, integration and administration of numerous environmental laws, initiatives and strategies across different industry sectors and tiers of government poses major challenges. The next section will briefly discuss the influence of international environmental strategies on the development of environmental laws, regulations and strategies in Australia across the three government sectors. The focus is on the issue of sustainability of the construction industry.

2. THE FEDERAL (COMMONWEALTH) GOVERNMENT

The Federal Government has wide ranging legislative powers over issues of national importance including the environment. The first wave of environmental protection legislations enacted in the mid 1970s and the early 1980s was a direct response to a growing awareness of the need to develop better environmental management standards as proposed by the UN Conference on the Human Environment in Stockholm 1972 and the World Conservation Strategy in 1980. The most notable legislations were the Environment Protection (Impact of Proposals) Act 1974, National Parks and Wildlife Conservation Act 1975 and World Heritage Properties Conservation Act 1983. Together, this legislation

attempted to halt the ecological vandalism across the entire spectrum of social, economic, cultural and environmental activities. Their principal aim was to create a better balance between economic development and social, cultural and environmental heritage.

The Brundtland Report (WCED, 1987), which defined sustainable development and the Montreal Protocol 1987 (Morrisete, 1989) which addressed the issue of global ozone depletion influenced the work on developing the Ecologically Sustainable Development (ESD) strategy in 1989 through the Federal Department of Environment. The ESD strategy was finalised in 1992 after long consultations with all levels of government, business, industry, academia, community and other relevant parties. It sets the Federal Government's broad strategic and policy framework on co-operative decisions and actions to pursue ESD in Australia. Its main objectives are to:

- enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations;
- provide for equity within and between generations, and
- protect biological diversity and maintain essential ecological processes and systems.

The Federal Government is generally not concerned with a regulatory framework for new developments. This is the domain of State Governments unless it is procured by a Federal Government agencies, in which case the Department of the Environment will assess its environmental impact under the Environment Protection (Impact of Proposals) Act 1974. The Federal Government may also intervene in the approval process of any new developments through a wide range of constitutional powers where heritage, social, cultural, economic or environmental issues of national importance are seen as being compromised.

On 31 October 1990, Federal and various State Governments and Territories agreed to develop an Intergovernmental Agreement on the Environment (IGAE), which came into effect on 1 May 1992. The aim of this strategy was to develop a united front to facilitate:

- a national approach to the environment;
- a better definition of the roles of the respective governments;
- less disputes between the Federal, States and Territories on environmental issues;
- greater certainty of Government and business decision making; and
- better environment protection.

The IGAE initiative resulted in the establishment of the National Environment Protection Council (NEPC) in 1994 under the National Environment Protection Council Act. Each State and territory have enacted complementary legislation establishing NEPC. It also established the Australian Building Codes Board (ABCB) for the purpose of developing nationally uniform technical building requirements as part of more efficient building regulatory system.

The Federal Government continued to introduce new environmental initiatives and strategies through the 1990s, partially in response to the growing pressure from within the Australian community and partially in response to international initiatives such as the Earth Summit 1992, Agenda 21 under the Rio Declaration and the Kyoto Protocol 1997. The most notable initiatives will now be briefly discussed.

2.1 The National Heritage Trust

The National Heritage Trust was created under the National Heritage Trust of Australia Act 1997 (EA, 1997) to fund a program of environmental protection and repair within Australia. It is the largest environmental rescue effort ever undertaken in Australia with a fund of $1.35

billion. It is a partnership of individuals, communities and governments who through specific projects target environmental problems affecting land, vegetation, rivers, coasts and marine, and biodiversity at their source.

2.2 Investing for Growth

In December 1997 the Prime Minister John Howard (ISR, 1997) in direct response to the Kyoto Protocol announced a strategy for the development of Australian industry. The aim was to work with business to promote industry growth and to develop Action Agendas to address impediments to growth in specific sectors while at the same time preserving environment and meeting Australian obligations under the Kyoto treaty. Although Australia emits little gases in total, its per capita emission is one of the highest in the world. "Investing for Growth" was an attempt to develop future strategies for lowering emission of greenhouse gases.

2.3 Building for Growth

Based on the Investing for Growth strategy, the Department of Industry, Science and Resources on advice from the National Building and Construction Committee (NatBACC) in 1988 issued a draft strategy known as Building for Growth (ISR, 1998). This was to serve as a blueprint for future development of the building and construction industry within the principles of sustainable development/construction and the principles laid down by the Kyoto treaty. In May 1999 the Federal Government after consulting with industry leaders endorsed the NatBACC's recommendations in *Building for Growth - Building and Construction Industries Action Agenda*, which among other recommendations promoted the use of voluntary codes and the establishment of the Australian Building Energy Council (ABEC) to advance energy efficiency in the industry.

2.4 The Australian Greenhouse Office (AGO)

The Federal Government established the Australian Greenhouse Office (AGO) in 1998 as a government agency to develop and drive a strategy on greenhouse matters. One of the key strategies that AGO administers is the National Greenhouse Strategy 1988 (AGO, 1998) which was formulated by the Federal, State and Territory Governments in response to the Kyoto treaty to provide a comprehensive approach to tackling greenhouse issues.

2.5 Report for Government by the National and Construction Committee (NatBACC)

This report, delivered to the Federal Government in 1999 by the NatBACC (ISR, 1999) included recommendations on the environment. The thrust of these recommendations was on the development of voluntary codes of practice for improving energy efficiency.

3. STATE GOVERNMENTS

Australia's State and Territory Governments develop and operate their own environmental laws and regulations in two specific areas of activities: in direct control of clean air and waters, noise pollution and waste, and in controlling new developments although the authority for control is delegated to Local Governments. These laws may vary from State to State but although not linked directly to the Federal Government legislations, they are nevertheless influenced by policies of the Federal Government. Since there is no uniformity in environmental laws and regulations, references will only be made to the regulatory framework of New South Wales.

3.1 Direct Environmental Control in NSW

The first environmental laws dealing with clean air, clean waters, pollution control and noise were introduced progressively between 1961 and 1975. These were enhanced by legislations

dealing with pesticides in 1978, environmentally hazardous chemicals in 1985, ozone protection in 1989 (in direct response to the Montreal Protocol), radiation control 1990 and unhealthy building land 1990. In 1991 the State Government introduced the Protection of the Environment Administration Act that established the Environment Protection Authority (EPA) in 1992 as a new statutory body responsible for administration environmental legislations, to a larger extent influenced by the development of the ESD strategy by the Federal Government.

Environmental legislations, including the Waste Minimisation and Management Act 1995, were amalgamated in 1997 into a new legislation titled the Protection of the Environment Operations Act (POEO Act) that came into force on July 1, 1999 (EPA, 1999).

3.2 Construct NSW

In response to the Building for Growth strategy, the NSW Government issued a visionary document about future opportunities, capabilities and challenges for its construction industry to year 2005, including the achievement of sustainable development.

4. LOCAL GOVERNMENT

In Australia, most new developments are administered and controlled by Local Governments, unless they are significant for the state or initiated by a state government authority in which case they are approved by the State Planning Minister. Local Governments play the most important role in achieving sustainable development particularly through the administration of development and building controls. While they have no legislative power and are required to administer relevant State laws, they nevertheless may impose local development and building regulations.

The legislation relevant to sustainable development that Local Governments in NSW administer is the Environmental Planning and Assessment Act 1979 (amended 1997). Through this Act Local Governments administer development and building controls within their respective localities. In terms of achieving sustainable development, the issues that Local Governments assess as part of the development application process include:

- statement of environmental effects of the proposed development on the environment;
- shadow and sun access;
- wind effects;
- energy efficiency and energy management strategy;
- ecological sustainability, and
- water conservation/management.

4.1 Local Agenda 21

Agenda 21 under the Rio Declaration recognised that Local Governments play a very important role in implementing the principles of sustainable development. Like many other countries Australia have responded to the Agenda 21 by developing Local Agenda 21, which provides a comprehensive list of priorities for achieving sustainability at the local level. This Agenda has already been embraced by many Local Governments with the assistance of the Federal Government in the form of the Environment Resource Officer scheme (ERO). This scheme employs dedicated environmental officers to help developing Local Agenda 21.

5. THE CONSTRUCTION INDUSTRY

Only recently and largely through government intervention has the Australian construction industry taken the first steps towards developing a strategy for achieving sustainable

construction. The initial commitment of the Federal Government to the Kyoto treaty provided an impetus for the development of the strategy known as Building for Growth (ISR, 1998). It was initiated by the Federal Government in association with the NatBACC, and has been embraced by the construction industry as a blueprint for achieving a healthy and profitable industry within the context of sustainable development, particularly in the areas of energy efficiency and waste minimisation.

Although far from being comprehensive, Building for Growth and its Action Agenda is nevertheless a step in the right direction. It aims to achieve sustainability through the use of voluntary environmental codes, and one important initiative has been the establishment of the Australian Building Energy Council (ABEC) by the Master Builders Australia in 1999 in collaboration with other industry bodies. The ABEC articulates the views of the construction industry on energy related matters and assists in formulating energy performance standards. It actively cooperates with the Australian Building Codes Board (ABCB) in the development of mandatory energy efficiency standards for the Building Code of Australia, based on the existing Nationwide House Energy Rating Scheme (NatHERS). ABEC also works towards the development of a voluntary Code of Practice for energy efficiency in buildings. The proposed Code will establish best practice for design, construction and management of buildings to reduce greenhouse gas emissions. A draft was presented to the industry in 2001 for comments.

6. A MAP OF THE REGULATORY FRAMEWORK

Figure 1 graphically portrays the regulatory framework that impacts on sustainable development in Australia. The framework depicts various environmental initiatives, strategies and laws at four different levels: international, national, state and local. It shows a complex array of relationships and influences within and across the four levels. One aspect highlighted by the map is the strong influence of international initiatives and strategies on the development of the Australian regulatory framework.

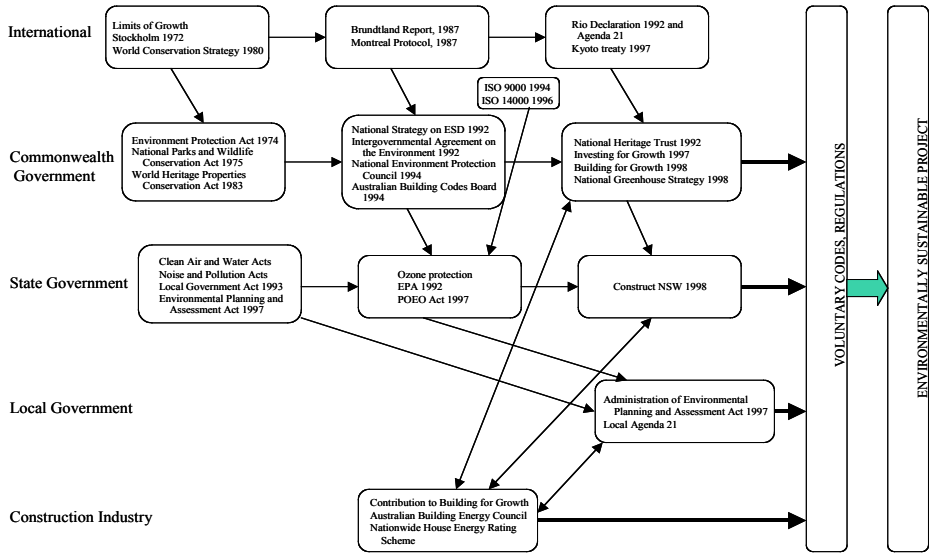

Figure 1 A map of the environmental regulatory framework in the Australian construction industry.

7. COMPULSORY REGULATIONS OR VOLUNTARY CODES?

While the construction industry in Australia is said to be heavily regulated, the contribution of environmental laws and regulations is relatively insignificant at present. The development and

application of strict environmental laws and regulations for enforcing future strategies arising from the Kyoto treaty, Investing for Growth or a range of environmental assessment methods that are currently being developed, may represent one possible way forward. Over-regulation is feared by the construction industry which advocates the use of industry voluntary codes instead.

Experiences with voluntary codes in other industries, such as broadcasting and advertising have not been encouraging and they raise doubt about effectiveness of voluntary codes in maintaining the desired performance standards. Whether or not voluntary codes will help to achieve sustainable construction will very much depend on the degree of commitment of the construction industry and its participants to the principles of sustainable construction over a period of time. The market itself, without such a commitment will not necessarily achieve the required behaviour, as prices will not reflect the evaluations of future generations and therefore not ensure intergenerational equity.

8. CONCLUSIONS

Australia's environmental policies and strategies have developed largely in response to international initiatives. These have been applied through a three tier regulatory system to control activities of the construction and other industries. The need to comply with future international treaties or environmental strategies of individual countries is likely to result in the development of new environmental laws and regulations. Fearing over-regulation, the construction industry prefers the development of voluntary codes. It is not as yet clear if there is a political commitment towards sustainable development sufficient to make such codes efficient.

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Towards Energy Sustainability in Small, Rural Communities

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INTRODUCTION

Progressing towards energy sustainability in small, rural communities frequently involves overcoming insufficient capital and expertise, and developing cost-effective and proportionate long-term solutions that can be maintained on an ongoing basis.

To meet these challenges, Yukon Development Corporation (YDC) and its subsidiaries, Energy Solutions Centre Inc. (ESC) and Yukon Energy Corporation (YEC), have developed a comprehensive, innovative and cooperative approach that involves targeted energy efficiency and renewable solutions. This has resulted in multiple benefits including the enhancement of local expertise, lower operating costs, reduced greenhouse gas emissions and economic activity.

This paper provides a brief review of the approach and activities taken by the companies to help realize the long-term goal of energy independence and sustainability.

CHALLENGES AND OPPORTUNITIES

The Yukon Territory, located east of Alaska, consists of a population of about 30,000 scattered in 18 primarily rural and remote communities over an area larger than the combined land mass of Germany, Netherlands and Belgium. With the exception of Whitehorse, all other towns and hamlets are comprised of less than 2,000 residents.

There is a heavy reliance on imported goods, many of which are transported almost 2100 kilometres to Whitehorse from the nearest major city in Alberta. Given the distance and small market, the Yukon is last on the supply chain and not a priority for many distributors. This means that securing new or specialty items such as energy technology can be more problematic than other jurisdictions.

The dependence on products from outside the territory also applies to refined fuels for heating, electricity generation and transportation, which increases expenses for Yukon people. For example, Whitehorse residents pay prices 11.5% and 25.7% higher than their counterparts in Vancouver and Edmonton respectively.[1]

[1] Yukon Bureau of Statistics, *Cost of Living Survey*, 1998, pp. 2 and 5.

Aside from the distance between communities, which increases the consumption of petroleum products for transportation, Yukon's dependence on fossil fuels is greater per capita than the Canadian average[2] because of its extensive use for heating and electricity generation. This reliance is exacerbated by the cold, sub-arctic climate that exists for seven months of the year with demand peaking in mid-winter.[3]

The Yukon enjoys an abundance of renewable energy sources including hydro electricity, wood and commercially viable wind but development has been hindered by the territory's small market, isolation and lack of technical capacity. Establishing new, primary power supply from renewable sources is often economically viable on a large scale, which entails access to a stable and large market. These conditions do not exist because of the Yukon's low population, economic volatility caused by fluctuating commodity prices and isolation from the North American electrical grid.

The Yukon has also faced rising costs for hydroelectricity because the power infrastructure was designed to accommodate large mining operations. Over the past decade, these customers have ceased operations. As customers disconnect from the grid, revenue for the utility drops, a surplus of generation capacity is created and the fixed costs are passed on to remaining consumers.[4]

A challenge to developing renewable energy sources has been the lack of local technical capacity. Renewable technology must be frequently adapted to the sub-arctic climate such as the significant modifications made to the wind turbines near Whitehorse.[5] And, these systems must be properly maintained to ensure operational efficiency and longevity under extreme climatic conditions.

Given this context, YDC, YEC and ESC have instigated a series of demand side management and renewable energy supply initiatives to displace or reduce the reliance on fossil fuels for heating and electricity generation. The long-term goal is to achieve energy sustainability and independence by transforming the local market so efficiency and renewable energy solutions become standard options rather than specialty features.

The approach is multi-faceted and relies on adaptation, innovation and partnerships with the public and private sectors. Cooperation and the pooling and leveraging of resources is necessary within such a small jurisdiction to ensure success. Initiatives are targeted to meet certain opportunities and needs within the market, and usually involve promotion and education, training and financial incentives.

DEMAND SIDE MANAGEMENT INITIATIVES

Demand side management activities have primarily focused on improving facility energy use, such as building design. The modern history of the Yukon is littered with examples of energy deficient structures due to inadequate attention to topography, soil conditions and the sub-arctic climate. The presence of permafrost alone has created unique and serious problems.

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[2] Cabinet Commission on Energy, Government of Yukon, *Energy Options for the Yukon*, 1998, pp. 5.
[3] Yukon Bureau of Statistics, *1999 Annual Statistical Review*, 2000, pp. 59-60.
[4] *Yukon Utilities Board Order 1998-5* (July 30, 1998)
[5] John Maissan, *Wind Power Development in Sub-arctic Conditions with Severe Rime Icing*, 2001.

This situation has been partly caused by the importation of building designs from southern Canadian jurisdictions that enjoy warmer weather and cheaper energy costs. The trend is most evident in national chains, which standardize structures, heating equipment and energy sources regardless of location. Inevitably, this leads to inefficient buildings and unnecessarily higher operating costs in sub-arctic regions.

For example, a recent audit of a franchise restaurant determined that the installation of a heat recovery system would yield permanent cost reductions while recouping the capital expense within three years.[6]

Despite better information on soil and climate conditions as well as improvements to building codes, energy efficiency, and renewable energy technology, poor building design still occurs due to a preoccupation with the up-front capital expense over long-term operation and maintenance costs. This perspective enjoys a certain entrenchment within the Yukon building industry due to the lower energy prices that existed in the 1970's and 1980's. As well, consumers and the building industry remain skeptical about the reliability, sophistication and cost effectiveness of efficiency and renewable energy technology.

To meet these challenges, ESC has liased with private and public sector clients[7] planning new buildings over the past year to encourage integrated energy solutions, and to demonstrate that incorporating efficiency and renewable technologies need not cost more in the design stage and provides long-term operational savings. Recommended solutions have varied from installing low-voltage lighting and timers to positioning a structure to maximize solar gain to implementing ground source heat pumps.

ESC has sought to shift the Yukon building industry to more of these solutions by holding Canada's first known Green Building Design Competition. The Competition engaged local architectural firms and aligned professions. It promoted the effectiveness of an integrated design process from the onset of a project[8] and provided a showcase for introducing new renewable technologies to the northern market[9].

The Competition supplemented this professional development opportunity with the RETScreen energy software analysis training developed by Natural Resources Canada. The introduction of this tool to the architectural community will further promote renewable energy solutions in building design and help determine the most appropriate technologies through technical and cost assessments.

The Yukon is a jurisdiction of independent, free-spirited and opinionated people and for this reason, government and related agencies have adopted an incentive based and voluntary approach to building design for the public and private sectors. However, the next step to maximizing energy use is to improve building energy performance for new institutional and commercial

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[6] Northern Climate Engineering Ltd., *Boston Pizza Energy Savings Study*, 2001, pp. 5.
[7] Energy Solutions Centre, *Energy Solutions Progress Report - Energy Solutions in Building Design*, 2002.
[8] Energy Solutions Centre, *Call for Expression of Interest, Green Building Design Competition*, 2002, pp. 1, 5 and 16.
[9] Energy Solutions Centre, *Call for Proposals, Green Building Design Competition*, 2002.

facilities through regulation. Initial discussions have occurred with the local construction community and it is anticipated these changes could become a reality in 2003.

Other demand side management activities by ESC have targeted residences in communities dependent on diesel-generated electricity. Reductions in fossil fuel power through household efficiency decrease consumer bills, provide utility savings by lowering operating costs and eliminate greenhouse gas emissions.

One such initiative, the House Calls Energy Efficiency Program, provided home visits to install an insulating blanket on the electric hot water tank and a compact fluorescent light bulb in a suitable location. High-quality, low-flow showerheads, sink aerators, sample receptacle gaskets and plastic window film were also supplied along with information on other energy saving products.[10]

This program reached over 1,500 homes or approximately 15% of Yukon housing stock. The average household savings totaled over $215 (CDN) while utility cost reductions amounted to $295,000 (CDN). Diesel-generated electricity was reduced by 7% throughout the territory, permanently eliminating an estimated 1,845 tonnes of carbon dioxide a year.[11]

As the next step towards reducing electricity consumption in communities reliant on diesel-generated power, ESC will launch the Yukon Energy Efficient Appliances for Home (YEEAH!) program. Since refrigerators, washing machines and dryers are the largest drivers of residential electricity bills, YEEAH! will promote the long-term cost savings of efficient appliances. It will also offer substantial rebates to change-out refrigerators ten years or older with new, efficient models in areas serviced by diesel-generated electricity.

These efforts compliment YDC's existing Residential Energy Management Program (REMP) designed to eliminate electric baseboard heating, which contributes to the need for diesel-generated power to meet winter peak demand in hydroelectric zones. REMP offers low-interest financing for consumers to install alternative heating sources.

ESC is also investigating demand side activities in the heating field. It has just completed a Neighbourhood Woodstove Change-out and Education Pilot Project to remove inefficient residential woodstoves in an area subject to winter thermal inversions. Their replacement with efficient, certified units improves air quality and visibility, reduces household energy costs and conserves timber resources.[12] This initiative may be expanded across the Yukon, as wood is the primary heating source for 25% of homes.[13]

Plans are underway to launch a pilot project to exchange old, residential oil-fired forced air furnaces with "best of class", appropriately sized integrated combo systems in a community

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[10] Energy Solutions Centre, *Energy Solutions Progress Report - House Calls Energy Efficiency Program* Results, 2002.
[11] Energy Solutions Centre, *Energy Solutions Progress Report - House Calls Energy Efficiency Program* Results, 2002.
[12] Energy Solutions Centre, *Energy Solutions Progress Report - Neighbourhood Woodstove Change-out and Education Pilot Project*, 2002
[13] Department of Economic Development, Government of Yukon, *Yukon Energy Resources – Wood*, 1997, pp. 2.

serviced by diesel-generated electricity. These systems use an oil-fired boiler to heat water for domestic use and transfers heat from the water through a fan coil for central heating. Heating fuel consumption is reduced due to the efficiency of the new unit and the elimination of the electric hot water tank lowers the need for diesel-generated power.

RENEWABLE SUPPLY SIDE DEVELOPMENT

Achieving the long-term goal of energy sustainability and independence requires developing local renewable energy sources while considering the barriers to infrastructure construction in the Yukon previously outlined in this paper.

The collaborative approach taken by YDC, ESC and YEC has been to maximize the use of the current hydroelectric surplus and to develop small-scale green power sources to partially or fully displace the use of fossil fuels for heating and electricity generation.

For example, a 223 kilometre transmission line will be completed from the Mayo hydro generating station to Dawson City in 2002 to replace primary diesel-produced power in that community with surplus, renewable hydroelectricity. The project will decrease territorial wide diesel-generated electricity by 40% and annually eliminate up to 16,800 tonnes of greenhouse gas emissions.[14]

The Renewable Power Sales Incentive Program targets the sale of available, surplus hydroelectricity to commercial and institutional customers for heating at a discounted price substantially lower than propane or heating oil. Eligible participants install electric boilers and/or heat pumps in addition to their existing fossil fuel heat source. This is because the sale of surplus hydroelectricity is on an interruptible basis with the utility disconnecting the electric heating source in the event power is needed for peak demand.

This situation is unlikely to occur in the medium term as a major industrial user is not expected to connect to the grid. As a result, the capital expense for the electric boiler or heat pump installation can usually be recouped through cost-savings within two to four years. Particular emphasis has been given to the tourism industry for this initiative as the highpoint of the summer visitation season coincides with the maximum output of hydroelectricity.

Considerable effort has also been dedicated to investigating the possibility of storing the current surplus hydroelectricity through hydrogen generation. This has led to a study examining the feasibility of hydrogen production, storage and transportation, and applications for off-grid camps, displacement of diesel-generated power, heavy equipment and related mining applications, fleet vehicles and peak power generation.[15]

YDC and YEC have aggressively pursued wind energy through the Community Wind Resource Assessment Program and Wind Research and Development component of the Green Power Initiative. Both initiatives advance the use of wind energy by monitoring potential sites throughout the territory and adapting turbines to withstand the extremes of the sub-arctic climate such as severe rime icing. These activities have positioned the Yukon as a wind energy leader in

[14] Yukon Energy Corporation, *2000 Annual Report*, pp. 38.
[15] GS Energy Systems Inc., *Yukon Hydrogen Feasibility Study*, October 2000, pp. 1.

cold weather conditions and enabled the territory to be the highest per capita generator of wind energy in Canada.

The companies are considering turbines for two communities as a result of an Expression of Interest for Green Power Installation issued by YDC in December 2000. The units would displace diesel-generated electricity and pending the final completion of the technical and economic feasibility study, may be implemented in late 2003.

CONCLUSION

Small, rural communities face significant challenges to achieving energy independence and sustainability, and may heavily rely on fossil fuels for heating and electricity generation.

One approach to overcoming these challenges is through a comprehensive, innovative and cooperative effort with the public and private sectors that focuses on improving building efficiency and better utilizing or enhancing local renewable supply. Although not specifically discussed within the confines of this paper, promotion, training, financial incentives and regulation are important tools to accomplishing these tasks.

The Yukon approach to energy management is gaining attention in Canada. Within the last two years, the territory has received six national awards for its progress in the areas of energy efficiency and renewable energy.

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Energy & Emission Assessment as a Supporting Design Tool for Sustainable Refurbishment of Buildings

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1. INTRODUCTION

There is an enormous potential for energy use reduction in the building sector, mainly related to space heating. The priority should be given to the refurbishment of existing buildings. The transfer of the low-energy strategies and technologies developed for new buildings could lead to significant change in total figures. On the other hand, a refurbishment reaching the minimum energy requirement only fixes the present situation for a long future period. Figure 1 illustrates in a very simplified way the possible developments.

The required energy to cover the heat demand in the building should be analysed from the point of view of energy sources (renewable or fossil, overall efficiency etc.). Figure 2 compares different energy systems in general, regardless the availability in the local condition and in time (based on data Kasser 1998 and Ladener 2001). The primary energy conversion factor is expressed here as the ratio of amount of energy required in the building and the amount of non renewable energy to be used elsewhere in the world for that reason. From this point of view, solar system accompanied by biomass combustion seems to be a very good solution. On the other hand, every plausible method of additional thermal insulation or other improvements of building envelope leading to energy demand reduction has the primary energy conversion factor reasonable deeper, if calculated in the similar way. (The embodied energy related to additional insulation and other layers taken into account.) Consequently, highest priority should be given to the energy demand reduction.

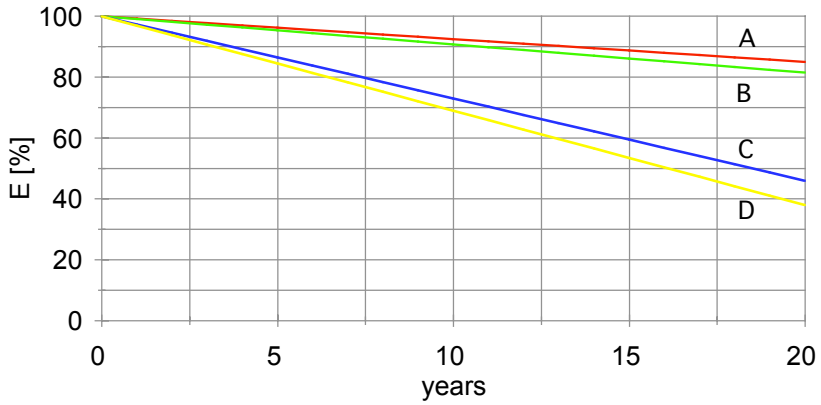

Figure 1 Optimistic prognosis of energy use for heating in general - simple parametric study (A – all new buildings (1 % per year) in low-energy standard (50 kWh/(m^{2}year), B – all new buildings (1 %) in passive-house standard (15 kWh/(m^{2}year), C – all new buildings (1 %) in low-energy standard + all refurbishments (3 %) with 70 kWh/(m^{2}year), D - all new buildings (1 %) with 30 kWh/(m^{2}year) + all refurbishments (3 %) with 50 kWh/(m^{2}year)

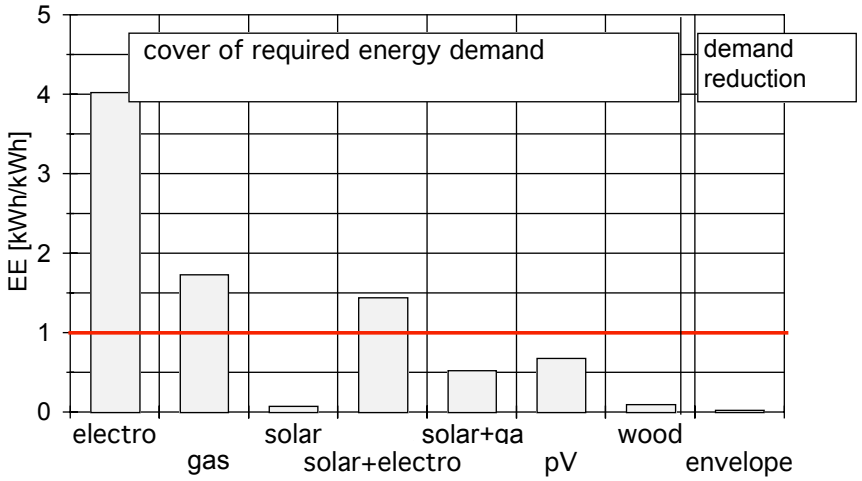

Figure 2 Energy media in comparison together with the improvement of building envelope (*solar* for small solar thermal system, all equipment included, *solar+electro* and *solar+gas* with solar energy covering 60 %, *pV* fotovoltaic, *wood* boilers for wood, wooden chips, small pellets, *envelope* energy improvement of building envelope)

2. REMARKS ON STRATEGIES, FOCUSED ON ENERGY ISSUES

In general, a system approach is urgently needed. On the very early stage of pre-design, the overall targets of the "action" should be discussed, evaluated and set. The alternatives expressed in the form of total energy values, equivalent carbon dioxide values (embodied + operation) should contain the "business as usual" (no-action), "common practice" (meeting the requirements), "better practice" or "best available" (BAT). If relevant, not only refurbishment of existing building structures and HVAC systems should be taken into account; a substantial extension of the building can be advantageous in particular case, too. If necessary, the published default values or unit-values evaluated from other, already finished projects can be used.

In the design stage, the target values for particular parts of the building envelope should be set - in the form of range and/or alternatives. It is very common that the targets and corresponding solutions have to be modified during the detailed design and constructing, reflecting the real conditions on site.

The larger new parts of the refurbished building, like extensions, new attics etc. should meet the energy criteria for new buildings (therefore additional assessed extra), on low-energy-building level, if possible.

Building physics should be involved in every refurbishment project intensively, for the whole period of preparing and constructing, focused on thermal performance phenomena (including thermal bridges, effects of air-tightness, water vapour transfer and condensation). Different studies and observations (e.g. Tywoniak 2000) report, that the real thermal performance could differ from the declared one in a significant way. It means that the embodied energy (embodied emissions) related to insulating material causing the environmental load is not exploited in the optimal way.

The use of a smart mechanical ventilation technique with heat recovery which is advantageous from energy reasons can bring "plus-points" in overall sustainability assessments (Green Building Challenge tools etc.) for better indoor-air quality.

All successful finished refurbishment projects of larger extension should be evaluated, reported and published in a proper way. It concerns especially the pilot-projects with the chance to be repeated.

3. EXAMPLE: KINDERGARTEN IN OSTRAVA-PROSKOVICE (CZ)

The refurbishment and substantial extension of existing kindergarten (built in 1978) is presented here – see basic data in Table 1. The net floor area will be increased from 637 m^2 to 1079 m^2 (170 %; new flats in the attics). Heat use related to 1 m^2 heated floor area is reduced from approx. 223 kWh/(m^2year) to 41 kWh/(m^2year)). In general, the renewable energy sources (solar+biomass) will be used for heating and hot water preparation. The primary (non renewable) energy use related to heating is reduced from 278 MWh/year to approx. 5 MWh/year.

In this pilot-project supported by Ministry of Environment of the Czech Republic, several analysis concerning both, embodied and operating energy and corresponding carbon dioxide values were performed. The design process was directly influenced by the results of such analysis. For example, the in the original design unexpected large excavations at the south facade (increasing of the load bearing capacity of subsoil) made the installation of the earth heat exchanger (pre-heating of fresh air) possible without higher costs.

	existing	refurbished + extended
U-value walls	1,0 W/(m^2K)	0,20 W/(m^2K)*
U-value flat roof	1,0 W/(m^2K)	not relevant
U-value pitched roof	--	0,16 W/(m^2K)*
U-value windows	2,9 W/(m^2K)	1,3 W/(m^2K)
slab-on-ground floor, floor slab	1,6 W/(m^2K)	0,7 W/(m^2K)
heated floor area (approx.)	637 m^2	1079 m^2
heat use related to 1 m^2 heated area**	223 kWh/(m^2year)	41 kWh/(m^2year)***
primary energy use (non renewable)	278 MWh/year	5 MWh/year
heating and ventilation system	natural gas boiler, natural ventilation	solar collector 120 m^2 + water storage tank 10 m^3 biomass heating, controlled ventilation with heat recovery + earth heat exchanger
use of renewable energy sources	0 %	100 % (36 % solar, 64 % biomass – wooden chips)
* energy effects of thermal bridges included ** based on EN 832 calculation *** 31 kWh/(m^2year) for new part extra		

Table 1 Short description of energy system

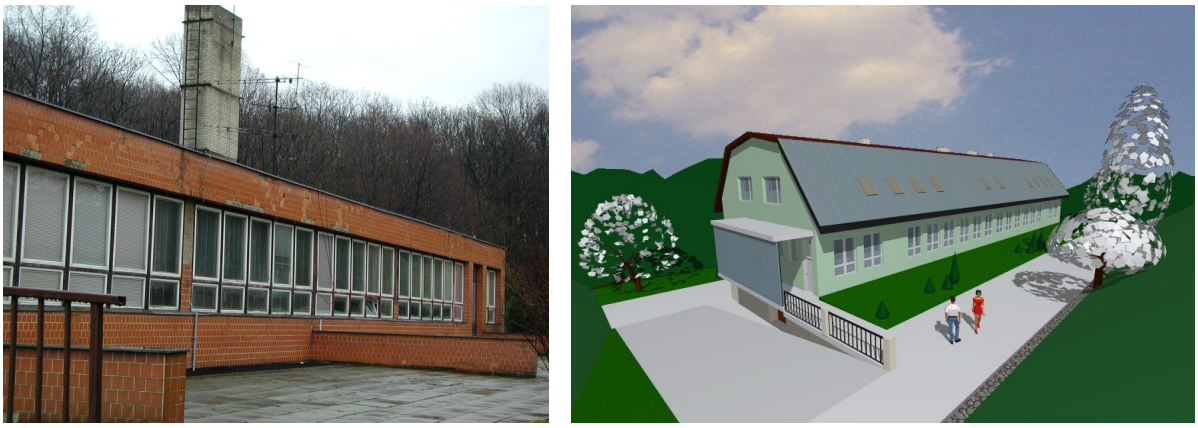

Figure 3 Kindergarten in Proskovice in year 2001 (left) and after substantial refurbishment and extension – expected in year 2003

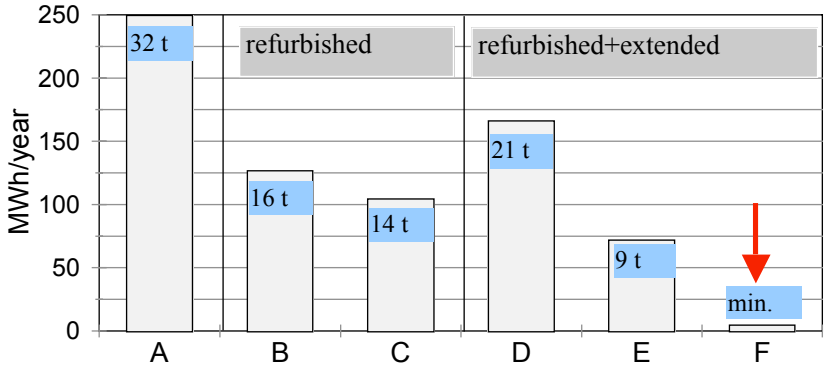

Figure 4 Kindergarten Proskovice - primary energy use for heating (MWh/year), comparison of alternatives (A existing, B-C refurbishment of building envelope (different level), D-F refurbishment + new attics, D corresponding the thermal transmittance requirements, E-F low-energy building with heat recovery from mechanical ventilation, A-F natural gas boiler, F thermal solar system+biomass heating). Yearly amount of carbon dioxide emissions related to heating in tons.

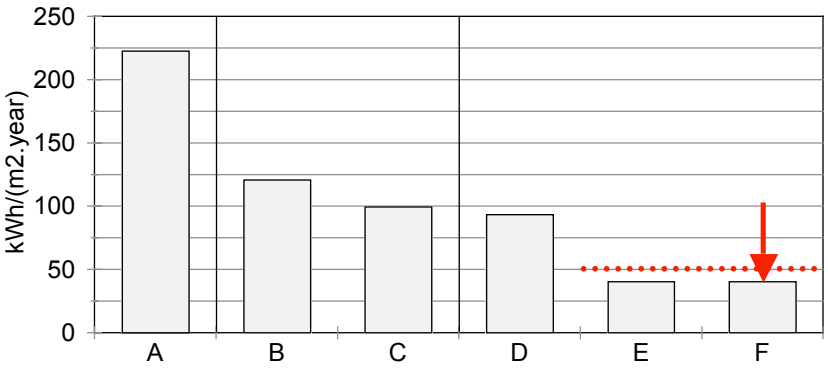

Figure 5 Kindergarten Proskovice - Heat use related to 1 m^2 heated floor area, comparison of alternatives (see Figure 4). The design solution reaches the target value for low-energy building (max. 50 kWh/(m^2year))

4. CONCLUSIONS

The refurbishment of kindergarten in Proskovice should be finished in spring 2003. Long-time observations and measurement of energy use, functionality of single components used here and the resultant indoor-air quality has already started. The most important data will be public available (on web pages). Roughly estimated, there are more than two thousands buildings in the Czech Republic in similar size and similar condition, especially on the countryside, waiting for their refurbishment. For that reason is the publicity on different levels very important.

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Managing sustainable construction – a steering model for the building process

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1. INTRODUCTION

A large part, about 40% according to Rees (1999), of the Earth's turnover of resources is associated with buildings and building construction. But this is not only a question about natural recourses; human resources and economic, social and cultural considerations are also involved.

A complex relationship must therefore be taken into consideration when realizing construction projects, since economic and social aspects also affect individual people. A major part of the decisions that affect the final building are made in the building process quite a long time before the building is finished. In order to gain an overall perspective on this relationship during the building process, one solution is to adapt the concept of *sustainable development* to the construction sector in order to produce *sustainable construction*, and to steer the building process in this direction and to find the main thread of the sustainability aspects of the project.

The purpose of this paper is to propose a model for steering the building process in the direction of sustainable construction. The work has been carried out in the form of a control model that has later been evaluated in case studies. The paper refers mainly to the Swedish construction sector, but it would be possible to adapt the model to the local urban conditions of other industrial countries. Some of the main conditions of the model would probably have to be modified in order to adapt it to other types of local conditions.

2. SUSTAINABLE CONSTRUCTION

The terms *sustainable development* and *sustainable construction* are relatively new in the construction sector. These terms have no simple definitions and confusion in understanding them is quite common in the sector. According to Agenda 21, sustainable development involves three main factors: ecological, economic and social development. According to Barrow (1997) it is necessary optimize these three main factors in order to achieve sustainable development. Kohler (1999) defined sustainable building in terms of these three factors.

Using Kohler´s model as a base, Persson (2001) produced an extended definition of sustainable construction including aspects of the urban areas of the industrial countries, actual legislation, the terms of Factor 10, the demands of the local markets and individual human rights of democratic influence.

3. THE URBAN MODEL

Attention must be paid to the issue of sustainable construction in all the decisions arising out of the complex web of considerations associated with a common construction project. Another obstacle to understanding is that sustainable development and sustainable construction are cross-disciplinary issues concerning **all** the players involved in the building process. It is easy to hand over a specific question to the next person in the chain of decision makers without formulating any reason, the ”solve one site” syndrome. As the project continues, all the project frames are set without addressing the issues of sustainable construction until it is too late for sustainability considerations. As the major part of the final cost of a construction project is set in the initial phase of the building process (Söderberg and Hansson 1993), the major part of the environmental and sustainability impact of the project is also fixed at the same time (indicated by Reed and Gordon 2000). As the building process continues, the decisions made have less effect of the final cost and the final environmental/sustainability impact of the project.

The following modell, *the urban model*, is proposed for controlling the building process according to the principles for sustainable construction for the urban areas of industrial countries. Its purpose is to create a main thread of sustainability priorities throughout the building process. The model is intended to optimize the sustainability goals and targets of the property owner’s organization and of the specific conditions, related to the site and to the purpose, of the actual construction project. The urban model is one aspect of the complete construction management process.

3.1 Structure of the urban model

The main structure of the urban model consists of a verifiable sustainability programme, which is set as early as possible in the process. The model includes measurable requirements, which are given priority from an environmental and sustainability point of view. Figure 1 shows the principle of the model and the main information flow. The model is not supposed to be static with all its requirements fixed at the programme stage. The function of the model is to be dynamic and to allow requirements to be changed as decisions and conditions changes during the building process. After the end of the project, the model supports the planning of maintenance and could be used as a base of sustainability information for users and tenants. The model has to be compatible with the environmental management system of the property owner’s organization.

The principle of the urban model can be described by three main boxes, containing the *specific conditions for the project*, the *general conditions of the property owner’s organization* and the *sustainability programme for the project.* The last-mentioned box act as a synthesis of the two first-mentioned and its concepts correspond to the environmental management standard of EN ISO 14001 (1996).

The specific conditions for the project contain parts of the *sustainability review, significant sustainability aspects* and *documented decisions* made during the building process.

The sustainability review is a review of the conditions specific of the site and surroundings of the building described in ecological, economic and social terms. With the sustainability review as a base, an evaluation of sustainability impacts is done, and significant sustainability aspects are set. The process of documenting decisions during the building process changes the

conditions for the final product - the building - and the conditions for sustainability targets on a continuous basis.

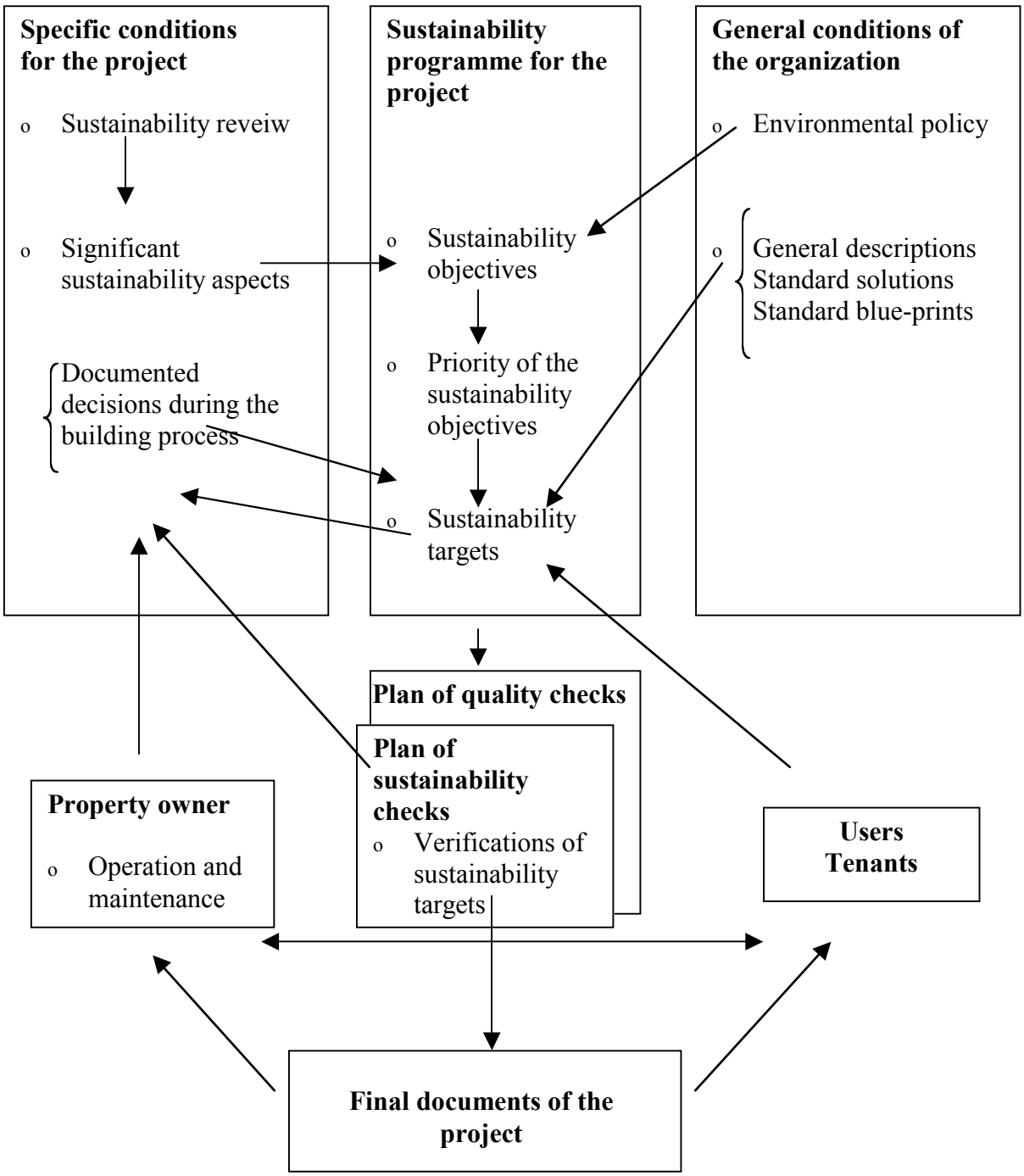

Figure 1 The principle of the urban model.

The general conditions of the property owner's organization include the project-related conditions, which are directly linked to the organization and its way of working. A main condition is the property owner's *environmental policy* and *environmental management system,* containing environmental objectives and the relevant parts of environmental targets. The general conditions of the property owner's organization also include conditions from

relevant *general descriptions*, *standard solutions* and *standard blueprints* according to the activities of the organization.
The sustainability programme for the project, which is a result of an analysis and of prioritizing the specific conditions of the project and of the general conditions of the organization, consists of three main parts: *the sustainability objectives, priority of the sustainability objectives* and *the sustainability targets.*

The sustainability objectives for the project depend on the environmental policy of the organization and the significant sustainability aspects of the sustainability review. This main part decides the direction of the project in a sustainability point of view; it formulates the main thread of the project as regards sustainability.

Priority of the sustainability objectives is a relative order of preference of sustainability objectives because of preparation for forthcoming relative conflicts and to meet other forthcoming demands of the project.

The sustainability targets are sustainability objectives in detailed and measurable units at levels from those of the system to those of single components. The methods of *verification* of the measurable sustainability targets are also established. It is possible to adjust the sustainability targets during the building process with confirmation in connection with documented decisions.

A plan of sustainability checks is drawn up by all players involved in the project, based on the verifiable sustainability targets. The aim is to verify all the sustainability targets according to the methods mentioned in the sustainability programme for the project. Divergence and change of verification are a part of the documented decisions. The plan of sustainability checks is a part of the plan of quality checks.

The sustainability programme for the project and the verifications according to the plans of sustainability checks act as the basis of the *final documents* for the project together with other documentation related to the project. From the final documents, sustainability information for the project is able to find its way to the property owner's organization for operation and maintenance, to users and to tenants, according to the organization's environmental management system.

The property owner's organization for operation and maintenance exerts influence on the project through documented decisions based on its experience of operation and preventive maintenance. It is important to have continuous dialogue between users/tenants and the property owner during the process. In this way the users/tenants can influence the sustainability targets.

The international standard for environmental management system, EN ISO 14001 (1996), is the basis of the main structure and the terms of environmental (sustainability) objectives and environmental (sustainability) targets. If the organization uses this standard for environmental management, it will find it easier to apply the model when it comes to environmental objectives, environmental targets and to adapting the final project to the organization's way of operating the building.

3.2 Case studies

Persson (2001) tried the urban model in three case studies. One study concerned "Futurum", a general concept for the green building of apartments in urban areas by Riksbyggen and Lund Institute of Technology. One study concerned a new commercial building, an office, "Tyrenshuset" by Whilborgs and Tyréns, Malmö, Sweden. The third study related to a major maintenance project for apartments by LKF, Lund, Sweden. Figure 2 shows the significant sustainability aspects as a result of the case studies.

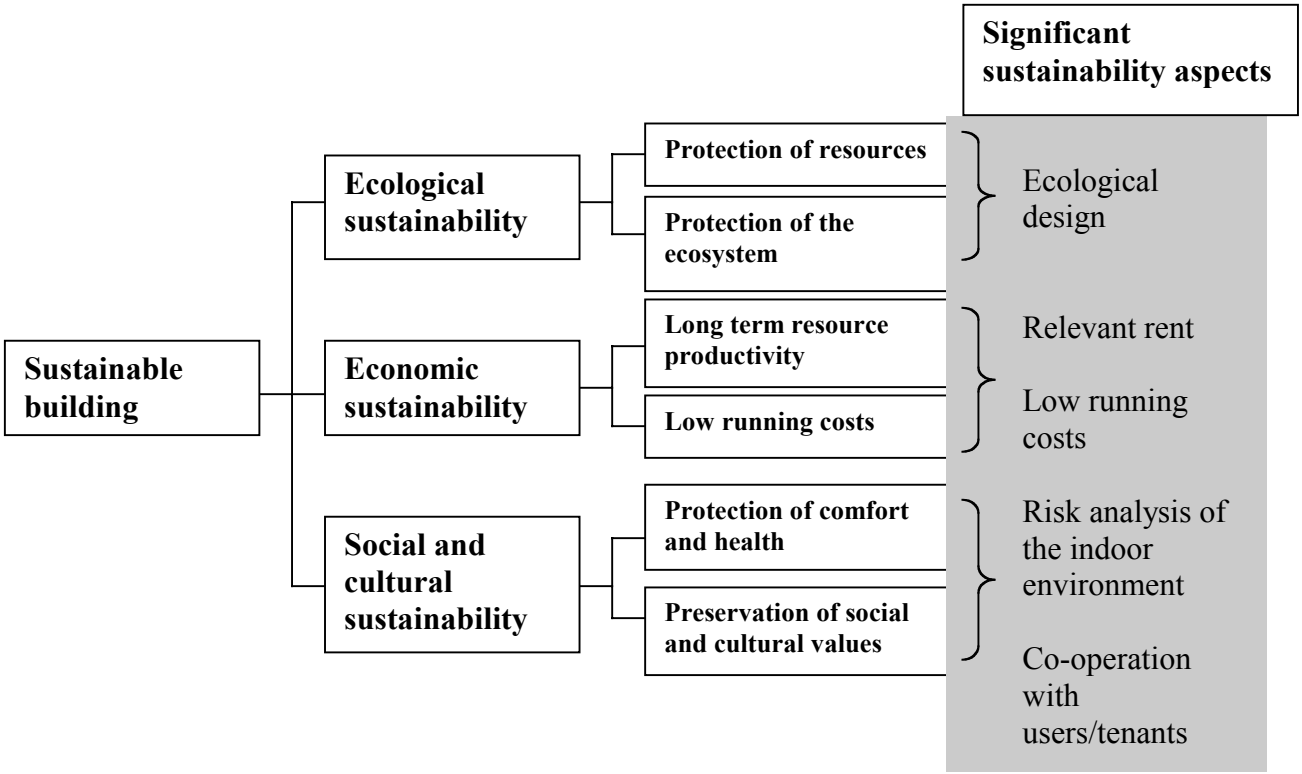

Figure 2 The significant sustainability aspects of the case studies of the urban model

4. CONCLUSION

The results of the case studies indicate that a sustainable construction requires optimization of the general significant sustainability aspects of ecological design, relevant rent for the users/tenants, low operating costs, co-operation between the property owner and the users/tenants and finally a well documented risk analysis of the indoor environment.

The procedure for steering construction in a sustainable direction depends on the specific nature of the construction project itself. The main aspect of sustainable construction is to steer the construction process from an overall perspective with respect to the level of sustainability potential that the property owner is able to achieve, the specific conditions for the project and the level of the organization's environmental management system. The urban model has the potential to make the environmental objectives of the organization accord with the sustainability objectives of the specific construction project and with the environmental objectives of the operational organization. Coupling these factors together with a sustainable building process ensures that the organization's demands for continual improvement is met and that the project's ecological, economic and social aspects are optimized.

The urban model needs to be improved to make it an easily managed, project-flexible and user-friendly tool. The model also needs to be evaluated in more case studies of different types of construction projects.

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Application of Integrated Life Cycle Design on Concrete Residential Buildings

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1. INTRODUCTION

Design and procurement based on whole life appraisal can improve functional quality and, therefore, the resource effectiveness of buildings. A building is a system that must satisfy several, often interacting, requirements, some of which can be measured quantitatively and some qualitatively. An integrated life cycle design approach will aid analysis and optimisation in pursuit of overall optimisation.

This paper presents findings from a study with the aim of enhancing the overall life cycle performance of concrete multi-dwelling buildings. For this purpose the application of Integrated Life Cycle Design, '*ILCD'*, is explored as a tool to predict and optimise the long-term characteristics, with regard to function and in particular economy and energy use. By introducing ILCD it is expected that the understanding of the relative significance of different functional aspects, economy and environment, and their correlation will increase. Thus the overall quality of the building, based on arbitrarily given priorities for a specific project, over its entire life cycle can be enhanced. Further to the traditional building design tools such as structural and building physical calculations, ILCD introduces methods for life cycle appraisal and multiple criteria decision making that have rarely been applied within the housing sector. Sarja (2002) presents an overview of the concept of ILCD. The study examines:

- important attributes of the multi-dwelling building
- the methodological aspects of ILCD, that is, how it can be applied on buildings
- methods for whole life appraisal with regard to the important attributes
- potential consequences regarding life cycle performance and in particular cost effectiveness and environmental performance that can be achieved by the application of ILCD on concrete multi-dwelling buildings

The practicability of ILCD has been explored by comparisons between calculated and actual performance with regard to life cycle costs and energy use on a few modern Swedish multi-dwelling buildings. Available life cycle data has been explored and a simplified method for multiple criteria decision making has been outlined incorporating quantitative parameters such as life cycle cost and life cycle energy use and qualitative data such as acoustics measured by performance classes. A tentative ILCD toolkit has been compiled comprising both commercially available software and databases and some especially designed spread-sheet modules.

2. THE BUILDING AS A SYSTEM AND THE PREDICTION TOOLS

2.1 Fundamental attributes of a multi-dwelling building

To design for optimal long-term performance of a building its fundamental properties must be addressed, quantified or classified and their relative importance assessed. Furthermore the interaction between properties and their dependence on the building frame, climate shell and the technical services systems must be considered. The complexity of the design situation is visualised in Figure 1.

Fire safety	+										
Hygiene, health (indoor climate)	+-	O									
Safety in use	+	+	+								
Acoustics	+-	+	+	O							
Energy economy	+	O	+-	O	+-						
Durability	+	+	+	+	O	+					
Global environment and recourses	+	O	+	+	+	+	+				
Robustness	+	+	+	+	+	+	+	+			
Flexibility	-	-	O	O	-	O	O	+	-		
Life cycle cost	+-	+-	O	O	-	+	+	+	+	+	
Aesthetics	O	-	O	-	-	+-	O	O	-	+-	+-
-: Improvement of one => impairment of the other. *O: No significant correlation* *+: Improvement of one => improvement of the other* *+-: Can work either way*	Mechanical resistance	Fire safety	Hygiene, health and…..	Safety in use	Acoustic	Energy economy	Durability	Global environment…..	Robustness	Flexibility	Life cycle cost

Figure 1 Selected attributes of multi-dwelling buildings and their tentative interrelations

2.2 Life Cycle Cost calculations for multi-dwelling buildings

Life cycle costs calculations for modern Swedish multi-dwelling buildings and statistics show that the relation between initial and operating costs is about 50/50 (Johansson and Öberg, 2001). The most important operating costs are refers to energy use, periodic maintenance and care-taking, which together constitute 50 to 70% of the operating cost. These operating costs are dependent on design choices. Data for periodic maintenance for materials and components such as maintenance intervals and cost per occasion are available, and used for property management. Potential energy use in a building and thus energy costs can be calculated. LCC, Life cycle costing or whole life costing is a well-established prediction instrument. Besides the quality of technical input data the accurateness of LCC is dependent on the real interest rate and the price change for a particular commodity in relation to the inflation. Looking over a long period of time the real interest rate fluctuates around a stable average. A LCC calculation for a dwelling building in the design phase covers a long period of time why the average real interest rate can be used. Price changes in relation to inflation must however be estimated and a sensitivity analysis can then be undertaken. For environmentally related commodities such as energy and waste treatment price increase above inflation is plausible.

2.3 Prediction of environmental performance of buildings

For buildings both the local - indoor climate - and the global environmental perspectives are relevant. To measure the environmental performance of a building quantitative environmental product declarations based on life cycle inventory for the components and materials that constitute the building can be used. The usage phase characteristics such as length of service life and maintenance programs is crucial information that is also needed for LCC. It should be stressed that the resulting environmental performance is governed by interaction between materials, components and systems and furthermore affected by the execution and by the behavior of the user. At present quantitative environmental product declarations are only available for a limited number of building products.

Several studies indicate that the energy required during the usage phase is the most important environmental aspect of buildings (BSK, 2001). 85% of the life cycle energy use refers to the usage phase (Adalberth, 2000). Energy use can thus be considered as simplified alternative way to assess global environmental performance of a building. Commercially available software can be applied in the design phase to predict energy use for alternative designs and the real performance of a building can be measured and declared. The energy balance program VIP+ (1994) was used for parametric studies after comparisons with measured values in a field study in Svedala were the difference between the calculated and the measured energy use was less than 10%. The programme can also indicate indoor temperatures.

From the view of design optimization some indoor climate parameters such as air quality can be regarded as a minimum requirements rather than a variables. Other aspects such as acoustics can be arranged in classes. Indoor climate in the finished building can be assessed by a questionnaire, which also was applied within the field study. This is a way to detect any deficiencies and to collect feed back on the performance of the designs for future projects.

2.4 Methods for multiple criteria optimisation

To organise the collection, interpretation and definition of the clients needs with regard to functionality Quality Function Deployment, '*QFD'*, can be applied. QFD is used to support product optimisation in the design phase and has been successfully applied in the manufacturing industry since the early 1980s. Akao (1990) defines QFD as a method for a) developing a design quality aimed at satisfying the customer and b) translating the consumers' demand into design targets and major quality assurance points to be used throughout the production stage. QFD is thus a systematic way for tuning the product features to the client requirements and for documenting the decisions in the design process.

Using the traditional tools alternative designs are outlined. The life cycle performance of these alternatives is assessed with LCC and LCA or energy balance calculations. To select the optimal alternative dealing with several quantitative and qualitative parameters multiple attribute decision making methods such as Multiple Attribute Decision Analyses, '*MADA',* (ASTM, 1998) can be applied. Some properties such mechanical resistance and stability are regulated by standards with a strict minimum quality requirement and are thus normally used only as screening attributes that is they are unconditional and higher quality levels are not rewarded. If higher structural capacity yields improved flexibility for future changes this attribute may however be included in the optimization. Any attribute may on the other hand be fixed as a screening attribute. For example a sound insulation class, date of completion or maximum life cycle cost may be unconditionally fixed. Attributes that are specified by performance or quality classes or verbal expressions are digitalized and the assessment procedure is based on paired comparisons. The method starts from a hierarchy expressed as a

tree structure. This structure is transformed into a decision matrix were the attributes are defined in one dimension and the performance of the studied alternatives in a second dimension. The next step is to perform pairwise comparisons between the alternatives with regard to each attribute. This is done with a matrix of pairwise comparisons answering the question how much more desirable is one alternative to the other. The same type of pairwise comparison is also performed between attributes were the question is how much more important is one attribute than the other. Note that this procedure can be used to compare a limited number of defined alternatives but not for some general optimisation.

3. INTEGRATED LIFE CYCLE DESIGN AN EXAMPLE

This example presents the application of integrated life cycle design on buildings. The attributes are taken from the evaluation criteria stated for the contest initiated by the Swedish Delegation on Building Costs (BKD, 2000): 40% Economy, expressed as rent, 20% indoor climate, 20% functional quality, 20% ecology and resource use. In the following example ecology and resource is exchanged for energy use and indoor climate is divided into three sub-attributes: acoustics, thermal comfort and indoor air quality. These are given a relative importance of 40, 20, 40 respectively. The Swedish building regulations should also be fulfilled, that is used as screening condition. In the contest the attributes were defined in further detail that is sub-attributes. A real building [A] that was used for verification of LCC and energy use calcalations is compared with two different alternative proposals [B, C].

According to MADA (ASTM, 1998) principles a tree-structure hierarchy is drawn up, see Figure 3. Life cycle costs and energy use are calculated for the alternatives and compiled in a decision matrix covering all attributes together with data for the other attributes, see Table 1.

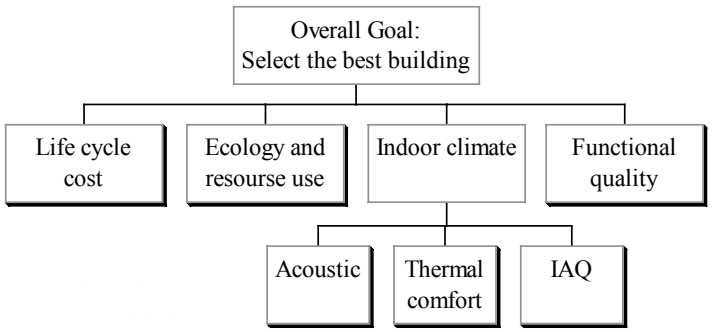

Figure 3 Hierarchy for the example with leaf attributes shaded

Table 1 Decision matrix

Attribute		Performance of alternative			
Level 1	Level 2	A	B	C	Unit
Life cycle cost. 50 y		1722	1778	1629	Euro/m²
Energy use. 50 y		6800	6460	7004	KWh/m²
Indoor climate	Acoustics	B	B	C	Sound Class
	Thermal comfort (indoor temp.)	36	12	60	Days/year >28°C
	Indoor air quality	Very good	Very good	Very good	Verbal
Functional quality		Excellent	Excellent	Good	Verbal

The decision matrix is processed with paired comparisons between

- the alternatives are for each leaf attribute
- the attributes for each attribute level

This can be conducted with a matrix of paired comparisons as shown in general principle in Table 2 and as an example for the first level attributes in Table 3. Table 4 shows the weighted values and the ranking is given by the sum, were the highest value is the preferred alternative.

Table 2 Matrix of pair wise comparisons according to ASTM (1998)

		Alternative or Attribute			
Alternative or Attribute		1	2		n
	1	1	Desirability of 1 over 2		Desirability of 1 over n
	2	Desirability of 2 over 1	1		
				1	
	N	Desirability of N over 1			1

Table 3 Pair wise comparisons of first level attributes in example

		40	20	20	20
		Life cycle economy	Ecology and resource use	Indoor climate	Functional quality
40	Life cycle economy	1	2	2	2
20	Energy use	0,5	1	1	1
20	Indoor climate	0,5	1	1	1
20	Functional quality	0,5	1	1	1

Table 4 Final ranking of alternatives in example

	Alternative A	Alternative B	Alternative C
Life cycle economy	0,40	0,388	0,408
Energy use	0,20	0,211	0,194
Acoustics	0,08	0,080	0,053
Thermal comfort	0,04	0,120	0,024
IAQ	0,08	0,080	0,080
Functional quality	0,20	0,200	0,120
Sum	**1**	**1,08**	**0,88**

4. CONCLUSION

About half the life cycle cost refer to the operation phase. Periodic maintenance, heating and care-taking are the most important items with regard to operation cost and they are all dependent on the design of the building. Data on periodic maintenance for different materials, systems and components are available. Heating costs can be estimated with energy balance programmes and care-taking and other costs can be determined on the basis of statistics.

The global environmental performance of a building can be assessed by the energy use during the operational phase, which can be predicted with an accurateness of +-10% with commercially available energy balance programmes. The programme must be able to deal with aspects such as solar radiation, thermal storage and air tightness to appreciate the impact of differences with regard to choice of materials and heating and ventilation systems. The real energy performance of a building can later be measeured and declared.

Indoor climate in existing buildings can be assessed by a standard questionnaire. This should be done on a regular basis for all large projects in order to identify problems and above all to collect knowledge for the design of subsequent projects. Choice of ventilation system and performance with regard to air tightness, resistance to humidity, thermal capacity to even out temperatures and thermal bridges are important parameters to observe by the design.

It has been shown that life cycle aspects could and should be considered to a higher extent within the construction sector. The impact of the built environment, and in particular the operational phase, regarding for instance energy use, waste streams and economy justifies a large design effort to optimise a building over the life cycle. A simplified procedure for integrated life-cycle design has been outlined comprising software for energy balance calculations, acoustic design, LCC and multiple criteria decision making. Tools for multiple criteria decision making can be used to optimise a design with regard not only to attributes that are measured quantitatively such as life cycle cost but also qualitatively, for example, aesthetics, robustness, flexibility and semi-quantitatively by classes such as sound insulation.

5. ACKNOWLEDGEMENTS

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LA 21 applied to Kvernhuset secondary school in Fredrikstad, Norway

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INTRODUCTION

The new building construction for Kvernhuset secondary school will be completed during the summer of 2002. The number of pupils will be 450–500.

A research and development project (R&D), supported by the national programme EcoBuild, is connected to the planning and building process. The focus is placed on making the building and yard functional and attractive for the school and the surrounding neigbourhood, while also making the physical structures environmental friendly. The school is part of the municipalities program for Local Agenda 21.

ARCHITECTURAL FEATURES

The school is situated in the suburbs of the city. Pine trees cover the site. There is a 3-5 m high drop in the terrain on the north part of the site, made by a long, steep, naked rock (figure 1). The main design idea of the school building is based on the active use of the site qualities: the rock, the forest and the light filtered by the trees. Wood and stones from the site will be used as building materials.

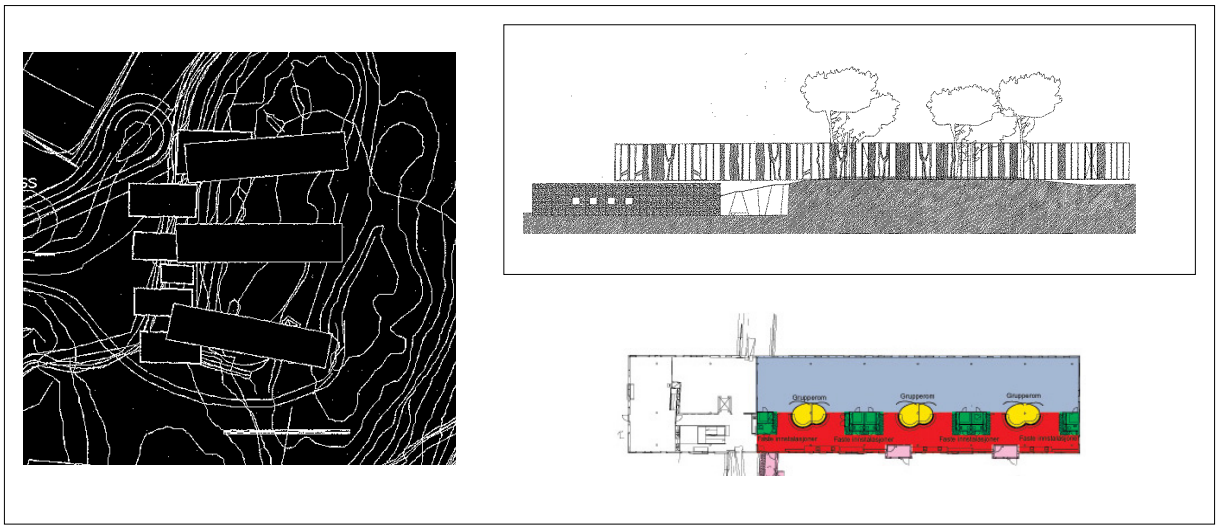

Figure 1 Site plan, south facade and plan of pupils base area

The first floor of the building cuts the rock. The burst rock mass is further used to face the first floor of the building. In this way the rock rises again. This time it makes rectangular

shapes oriented perpendicular to the rock direction. On top of the rock there are three rectangular, long and narrow wings that almost float over the ground. The wings' façades testify to the design inspiration of the surrounding trees (figure 1), and each wing has a slight strain of one of the colours: yellow, green or blue. The three wings have a light architectural expression that makes a strong contrast to the ground floor. The home bases for the pupils are situated in the wings.

OBJECTIVES OF THE R&D PROJECT

The overall aim is to obtain knowledge about environmental friendly school buildings and to disseminate the knowledge to school planners.

Objectives are:

1. According to standard practice the school building should be area efficient and adaptable to various working methods.
2. The school building and yard should be used as teaching tools to support the Nature and Environment studies.
3. The school building should have low purchased energy consumption in respect to space heating, ventilation and artificial lighting. Renewable energy should be utilised when possible.
4. According to the Norwegian assessment method 'EcoProfile' the school building and yard should obtain the best quality class for each of the three main areas: *Environment, Resources and Indoor climate.*

AREA ADAPTABILITY

Space efficiency and building flexibility are probably the factors that contribute the most to reducing the consumption of resources from a life cycle perspective. One objective, when designing base areas, was to create flexible buildings adaptable to different functions. The school should have the possibility to experiment with different pedagogical settings. Rooms and furniture should be adaptable to various working methods. The wings with the pupils base areas consist of three zones: area for classes, 'spine' and common area.

- The basis for the classes area is an unbroken area which can be divided into conventional classrooms, double classrooms, school landscapes or pupils 'offices'. It is also possible to combine these alternatives. The design challenge is to create an infrastructure that favours flexibility.
- The wardrobes and all rooms with fix installations are placed in the 'spine' which also serve as a separating element between class areas and common areas.
- Tthe common area contains a zone along the facade equipped with workbenches, washing troughs, aquarium and 'window gardens'. The common area is meant to be a rough supplement to the class area.

Walls can be placed in the construction axes and elsewhere the room can be connected to valves for inlet and outlet ventilation air. This means that a separated room has to be placed next to the spine to get inlet air, and at the same time has access to the dampers for outlet air in the base of the skylights. Lage rooms may be divided into zones by means of light walls, book shelves, screens, plant cases, aquarium and trees. Changes may easily be accomplished and the pupils and teachers themselves can arrange and rearrange the lay-out of their area.

SCHOOL BUILDING AND YARD AS TEACHING TOOLS

Area adaptability, energy saving strategies and ecological cycles are the measures to reduce consumption of resources. The objective is to manifest measures that contribute to sustainability such that the measures have a demonstration and teaching effect. With demonstration in mind, or thinking of the school building and yard as teaching tools, three levels are defined:

The first level is to demonstrate solutions chosen for the whole building complex. Special emphasis is given to:

- Exploitation of daylight
- Exploitation of natural driving forces for ventilation
- Exploitation of geothermal heat (heat pump)
- Natural cleaning of waste water, both grey and black water

The second level deals with measures that are too expensive or, for some other reason, not suitable as a solution for the whole building complex. The pupils' base areas are divided into three sections which each will have different installations for demonstration:

- Section YELLOW with focus on solar energy. Active and passive use of solar energy. Solar collectors and solar cells. Monitoring of energy use.
- Section GREEN with focus on growth and recycling of materials. Vegetables and plants inside and outside. Ecological cycles.
- Section BLUE with focus on water. Collecting water from the roof. Water saving armatures in toilets and wash basins.

The third level deals with devices which facilite ecology studies (terrarium, aquarium, apparatus), and art decorations to highlight ecological aspects.

ANALYSIS OF DAYLIGHTING CONDITIONS

Daylight is used to reduce the consumption of high-grade electric energy for artificial lighting and, at the same time, enhance architectural value. Separately operating zones for artificial lighting, and control by daylight sensors contribute to energy efficiency.

Alternative section designs were examined to rise the daylight levels, compared to the base case. Requirements to daylight levels were set for this project as shown in the table below.

Table 1 Requirements to daylight levels

Space category	**Average daylight factor**	**Minimum daylight factor**
All education areas Gymnasium	5 %	2 %
Workplaces for teachers Offices for the administration staff	3 %	1 %
Secondary rooms	(2 %)	-

Parametric studies for each alternative was carried out to find the minimum glazing area satisfying daylighting requirements, and to find the optimal form and placement of the additional daylighting openings in the room. The daylight simulations were made using the LesoDial data program.

Analysis show that the simplest and most effective alternative for the base area is the combination of large windows and skylights over the rear part of the classrooms. Large windows facing north and skylights result in high daylight levels.

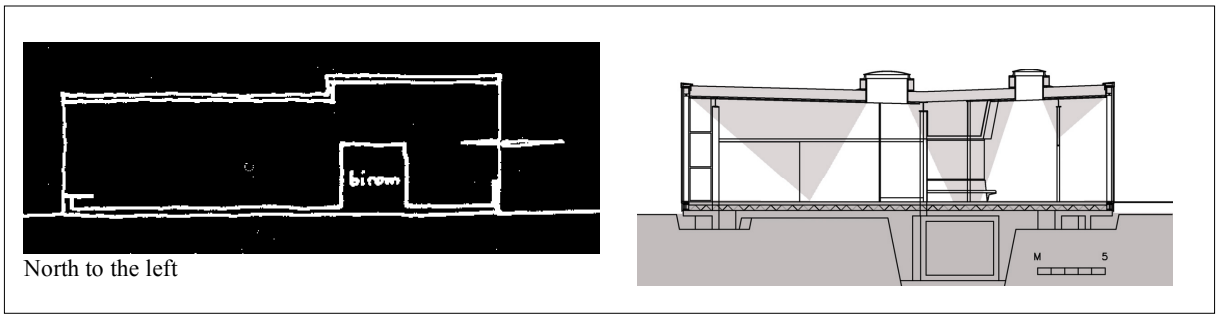

Figure 2 Vertical section of pupils base area. Drawing from the architect's competition design (base case) to the left. As built, with additional skylights, to the right.

The outside walls are a compound of opaque wall elements, clear glass elements and elements with the transparent insolation material ISOFLEX.

Table 2 Specification of wall elements in north facing walls in base areas

Element	**Light trans-mission factor**	**Per cent of wall area**
Clear glass elements made of two layers of glass	76 %	30 %
Elements with ISOFLEX, semitransparent material placed between glass layers	36 %	30 %
Opaque wall elements made of light wood construction	-	40 %

A second parametric study was carried out to find how the size of the skylights influence the minimum size of the transparent part of the wall, i.e. clear glazing and ISOFLEX glazing. The clear glass area and the ISOFLEX area were calculated for different numbers and sizes of skylights in order to find a solution that gives high daylight levels and at the same time the lowest possible heat loss.

VENTILATION

The building is provided with a ventilation system based on culverts. The airflow rate and the climatisation will be adjusted for the various seasons. In plan 1 there is a mechanical driven ventilation. In plan 2 natural driving forces, buoyancy and wind, are used for ventilation. This results in a minimum of power used for auxiliary fans. Demand control of airflow and low-emitting building materials will further contribute to energy efficiency. Heat recovery is installed for the mechanical driven system.

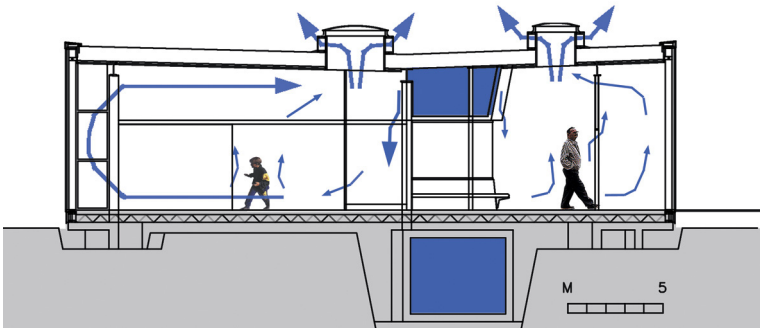

Figure 3 Section through pupils' base area, plan 2. Ventilation air is led from the culvert via shafts to a distribution chamber over the secondary rooms ('spine'). The inlet air will sink to the floor because it is a few degrees colder than the room air. The exhausted air evacuate via the base of the skylights.

WATER CLEANING

Both grey and black water will be cleaned on site. A NAVA Bed plant will clean the wastewater according to nature's own principals. Micro-organisms in a bio-filter will break down organic materials in the wastewater, and the phosphor will be tied up in special extruded concrete pellets in the phosphor filter. When the pellets are saturated by phosphor, they will be replaced by new ones. The used pellets, containing a lot of calcium in addition to the phosphor absorbed, will be used as soil amendment medium.

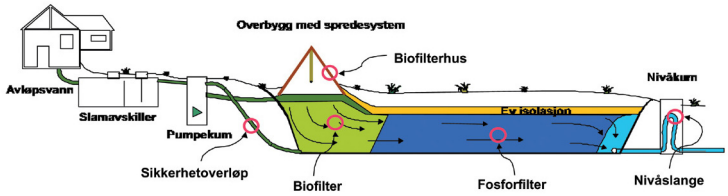

Figure 4 Sketch of a NAVA Bed plant.

ENERGY ANALYSES

The energy demand was simulated by means of the Norwegian computer program *Energy in Buildings,* version 3.0, ProgramByggerne ANS, 2001. This program is based on a dynamic computational model that takes into account the thermal mass of the building and simultaneous loads. The total energy load is comprised of energy for heating, cooling, ventilation, lights, and equipment. The efficiencies of the equipment and the energy sources have been taken into account. Control systems for heating, ventilation and lights have been simulated.

Weather data for the nearest meteorological station, which is Halden, has been used. This includes mean temperature, solar radiation, humidity and wind speed.

Results of the energy analysis

The simulations show that the purchased energy is 120 kWh/m^2/year heated floor area, of which 100 kWh/m^2/year is electricity and the rest is based on oil. This is well below experience from other similar buildings, which have an average energy use of 200 kWh/m^2/year. The benchmark for energy efficient schools in this climate, is 116 kWh/m^2/year.

ENVIRONMENTAL ASSESSMENT

A simplified environmental assessment has been performed during the design of the building. The assessment is based on EcoProfile, which is the only Norwegian method for environmental assessment of buildings. Due to the fact that EcoProfile is primarily used for existing dwellings and office buildings, some adjustments of the method has been done in order to make it suitable for school buildings during design.

Classification and weighting

EcoProfile classifies a building based on three main criteria: *Outdoor environment, Resources*, and *Indoor Environment*. These main criteria have many sub-criteria. The criteria are assessed in three classes: class 1 is ”low environmental loading”, class 2 is ”medium environmental loading” and class 3 is ”high environmental loading”.

Results

The environmental assessment shows that the school design performs relatively well on all environmental criteria. An evaluation of the finished building will show if the environmental goals will be fulfilled. The bar graph shows the result of the EcoProfile analysis. The project is classified in the best category: ”low environmental loading” for all the main criteria. The star diagrams give a closer look at the sub-criteria.

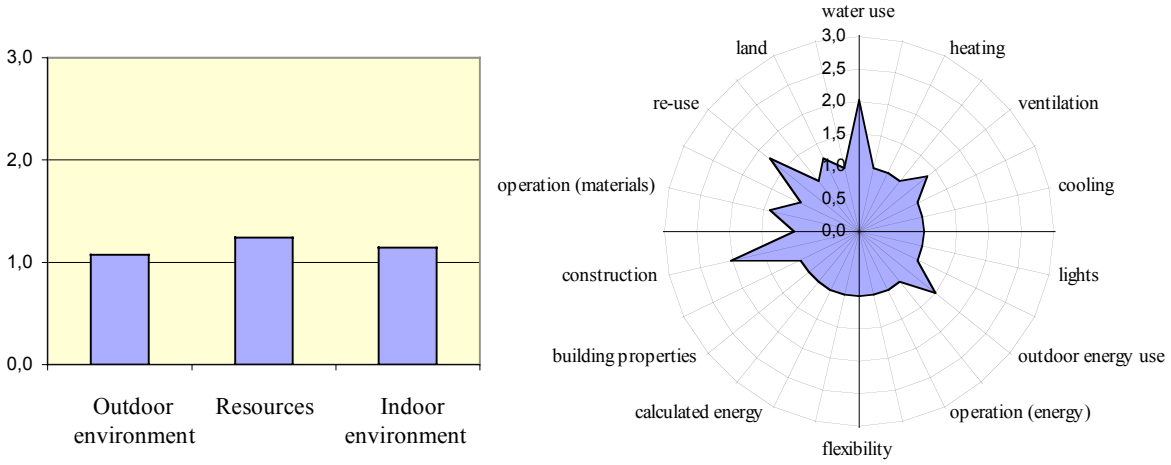

Figure 5 Results of the assessment. EcoProfile star diagram for *Resources* to the right.

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Efforts in making school buildings environmental friendly

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INTRODUCTION

Three Norwegian schools have been selected to illustrate the 'green building challenge':

1. The Grong School and Community House. Renovation and extension. The focus is on area efficiency and energy savings.
2. The Kvernhuset School. New construction. The focus is on the school's building and yard as teaching tools to support the environmental studies.
3. The Borgen School. Comprehensive renovation. The focus is on getting light and air into a building from the 60's, and making the building adaptable to various pedagogical settings.

The Grong School got financial support from national R&D funding (NVE and NFR) plus from the EU programme THERMIE (the MEDUCA project). The Kvernhuset and Borgen schools get support from the national programme EcoBuild.

The overall goal is to create buildings and yards, which are functional and attractive for both the schools and the surrounding neighbourhoods. The objectives are to optimise the use of space, to make green buildings with good indoor climates, and to lower energy consumption.

Children today learn about sustainability at school, but too often there is a gap between what they learn from their books and what they experience in their surroundings. The ambitious aim of these projects is to reduce this gap.

AREA ADAPTABILITY AND SHARED USE

Space efficiency and building flexibility are probably the factors that contribute the most to reducing the consumption of resources from a life cycle perspective. One objective when designing base areas was to create flexible buildings adaptable to different functions. The schools should have the possibility to experiment with different pedagogical settings. Rooms and furniture should be adaptable to various working methods.

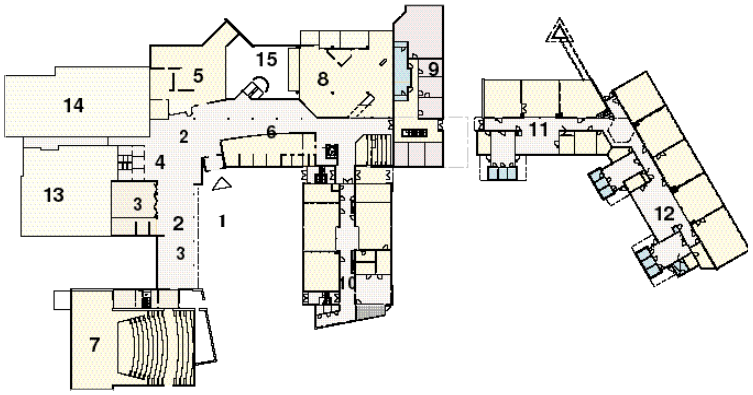
In the three schools the base areas can be divided into conventional classrooms, double classrooms, school landscapes or pupils 'offices'. It is also possible to combine these alternatives. The design challenge is to create an infrastructure that favours flexibility.

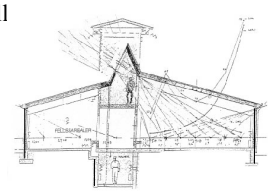
In order to create a 'living' local community and meet the need for the more efficient use of resources, joint location and co-ordinated use of facilities are emphasised. The goal is to increase the possibilities for the local community to use the premises, and thereby obtain social and economic benefits. Space limitations are often very strict, and suitable combination solutions must be found. Space can be saved by letting various user groups share areas, and having areas suited for several functions. Shared areas require a high degree of accessibility. Multifunctional areas require a high degree of adaptability.

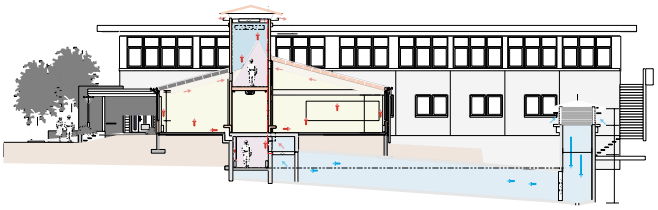
ARCHITECTURAL FEATURES

Efforts are made on addressing area efficiency, energy saving measures and the use of renewable energy. Exploitation of daylight and natural driving forces for ventilation are part of the strategies for energy savings. The Grong School has an active solar application integrated in the daylighting and ventilation aperture. The Kvernhuset and Borgen schools have a geothermal heat plant installed. The Kvernhuset School has a water cleaning plant on the site as well.

1 main entrance
2 vestibule
3 exhibition
4 wardrobe
5 café
6 homemaking
7 amphitheatre
8 library
9 administration
10 13-15 years old
11 10-12 years old
12 6-9 years old
13 swimming pool
14 gym/assembly hall
15 hall



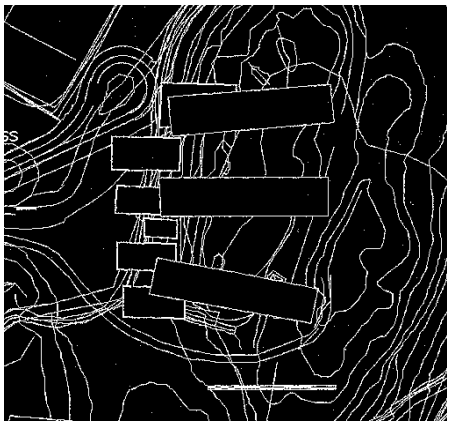


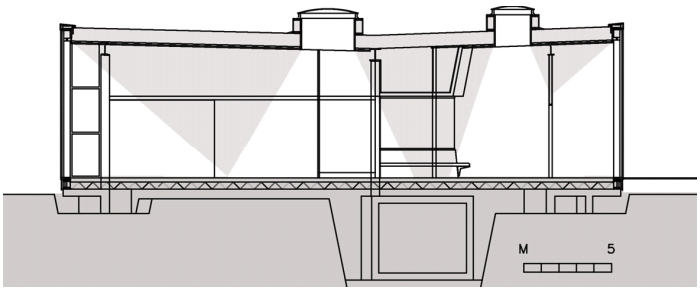


The Grong School has a joint location with a community house. One main task was to find a suitable solution for shared use of space.

A new wing has been fitted with an integrated solar, daylighting and ventilation solution.

Figure 1 Grong School and Community House. Plan and sections

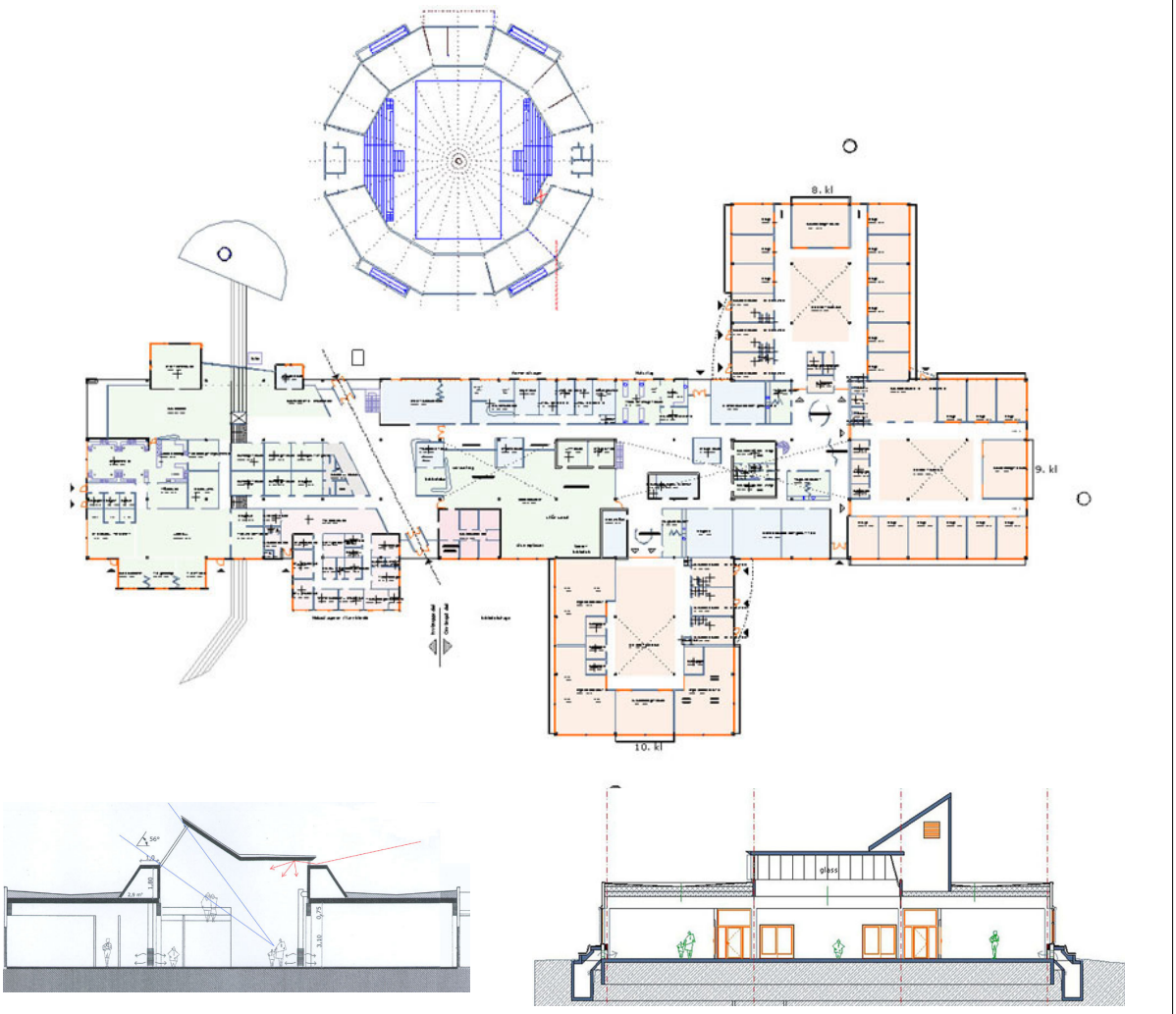




The Kvernhuset School is an integral part of the municipalities program for LA. 21.

The pupils' base areas are divided into three sections, each of which have different installations for demonstration: Section YELLOW will focus on solar energy. Section GREEN will focus on growth and recycling of materials. Section BLUE will focus on water.

Figure 2 Kvernhuset School. Site plan and section



The Borgen School in Asker is going to be part of a new community centre.

The existing building is poorly ventilated, has minimum daylighting, and is not fit for modern working methods. The roof coat will be replaced and daylight will be allowed inside. The building structure will be kept and strengthened with more beams. The windows will be enlarged and upgraded with respect to thermal insulation and solar shading. The bricks left over will be reused in internal walls.

Figure 3 Borgen School. Plan and sections

STRATEGIES FOR LOWER ENERGY CONSUMPTION

In aiming to reduce the consumption of energy the following stepwise strategy for design were used: initially apply energy efficiency measures, then utilise renewable energy resources, and lastly supply remaining demand with ‘clean fossil fuels’.

PASSIVE SOLAR DESIGN

Passive solar design can improve building energy performance in three areas: building heating, cooling and lighting.

Cost-effectiveness, robustness and user-friendliness will be in focus when integrating different passive strategies and technologies into building concepts.

Heating
Utilisation of solar energy can substantially reduce the energy demand for space heating.

Where heating is the dominant need, one principal façade is ideally oriented south for maximum exploitation of solar energy. South-facing surfaces receive more solar radiation in winter and less in summer when compared with surfaces with east or west orientations. This is approximately in phase with the heating requirements. Thermal mass can store heat produced by solar gain and release it as interior temperatures fall. And warm air from the south side can be canalised to the colder north side.

Shading should prevent overheating in the warm season. Windows on east or west facades are often the cause of overheating. They are difficult to shade effectively because of the low angle of sun radiation.

In school buildings at northern latitudes the advantage of daylight gained through large windows on the north façade may more than balance the heat losses through the windows. North-facing windows have no need for solar shading and glare reduction devices.

Cooling
Reduction of internal loads is the starting point for any project. Efficient appliances and lighting can minimise internal gains. Relevant cooling strategies are use of thermal mass, night cooling, high ceilings, solar shading, and forced natural ventilation by means of solar chimneys. Outdoor strategies are use of external vegetation for sun shading, ground cover planting and water features to provide evaporative cooling.

The most efficient way of protecting a building from unwanted direct sunlight is to shade the building's envelope or daylighting apertures. The degree and type of shade necessary depends on the position of the sun and the geometry of the building. Shutters, blinds, louvers, awnings and curtains are all examples of adjustable shading devices. Some of them can also be used in winter to increase thermal insulation. Ideally, shading devices should be moveable and placed on the exterior.

The possibility to reduce or eliminate the need for mechanical cooling depends on the thermal comfort requirements. Very strict requirements on temperature fluctuation, which is common in modern commercial buildings today, drastically increase the need for mechanical cooling. Less restricted temperature control is usually accepted in naturally ventilated buildings. Adaptive thermal comfort means that airflow rates and temperature levels will be adjusted according to season.

Daylighting
The importance of natural light for our well-being is well known. Letting daylight into buildings will often enhance the architectural value as well.

Utilising daylight will influence the energy use in buildings. Control systems for artificial lighting based on daylight sensors can reduce the consumption of high-grade electric energy substantially. Some of the electricity for the artificial lighting is being transformed to heat. Utilisation of daylight will thus influence the use of electricity for both lighting and cooling. At the same time the energy use for heating, in periods with heat demand, may be increased. However, for heating buildings lower-grade thermal energy can be used.

Various devices may be used to capture daylight and direct it deep into buildings and to reduce excessive light levels near glazing, providing a more uniform spread of natural light. Some of these, such as atria, light shelves, roof monitors and clerestory lighting can have profound architectural design implications. Others, such as prismatic glazing, reflective blinds and shading systems, can be more easily applied in the case of existing buildings. A wide range of specially treated glazing materials able to control the intensity and optical properties of daylight and heat flows through windows, is now available.

Daylighting analyses of the three schools

Alternative section designs were examined to raise the daylight levels compared to the base case. Parametric studies for each alternative were carried out to find the minimum glazing area satisfying daylighting requirements, and to find the optimal form and placing of the additional daylighting openings in the room. The daylight simulations were made using the LesoDial computer program.

For two of the schools a model of a typical section of the building was analysed, using an artificial sky and sun. A searchlight with a diameter of 40 cm and parallel rays was used to simulate the sun. The model was placed on a solar machine, which enabled precise adjustment of sun positions. The following sun positions were modelled: June 21 (summer solstice), March/September 21(equinox), December 21 (winter solstice), all at 10:00 am.

BUILDING INTEGRATED VENTILATION

Utilisation of natural driving forces, buoyancy and wind, will reduce the need for fan power. Low-emitting building materials and demand-controlled airflow rates will further contribute to energy savings.

One challenge is to combine natural and hybrid ventilation with other passive solutions, e.g. techniques and models coupling passive solar utilisation with preheating of ventilation air in wintertime, and enhancement of the stack effect in summertime.

High ceilings were a common strategy to reduce the demand for ventilation in old buildings. High ceiling and large room volume are used as a ventilation buffer, which is particularly effective in rooms with intermittent occupancy. If high ceilings are used in combination with displacement ventilation, the air flow rate requirement can be reduced significantly.

Heat recovery is traditionally a technology for mechanical ventilation. If heat recovery is developed further in natural ventilation systems, the total energy savings will be large, adding heating savings due to heat recovery to the savings in electricity for fans.

Design philosophy for the three schools

- Low-emission building materials. Restriction of contaminants introduced to clean zones (i.e. leaving outdoor shoes and cloths in the wardrobe). Easy inspection and cleaning of ventilation airways
- Use of passive measures such as high ceilings, thermal mass to reduce daily temperature swings. Earth-coupled air flow paths (underground culverts) contribute to preheating ventilation air in wintertime and cooling ventilation air in summertime
- Solar shading
- Minimise internal loads from artificial lighting

- Ventilation intake tower designed to protect from precipitation and to utilise wind forces
- Displacement ventilation utilising 'body plume' for transport of fresh air to breathing zone of occupants
- Demand controlled ventilation in rooms by sensing lower end of the warm and contaminated upper zone
- Ventilation airflow driven by buoyancy and wind combined with supply and extract fans
- BEMS, along with sensors for temperature, CO_2 and RH ensure demand controlled ventilation 24 hours a day. Automatic shut down to minimum ventilation driven only by natural forces when temperature levels are below set values
- Heat recovery from exhaust air by a loop system
- Exhaust tower with outlet valves that protect against intrusion of cold air and moisture, and that create suction by wind from any direction
- Occupancy monitoring of IAQ. Opening of windows is not needed for ventilation. Opening of windows is possible. Ventilation system will normally adapt to window opening

CONTROL

Before mechanical ventilation, cooling and artificial lighting were common in buildings, the indoor climate was dependent on passive strategies such as stack driven natural ventilation, window ventilation, large room volumes/high ceilings, thermal mass and window frame design for maximising daylight utilisation and limiting direct solar gain.

In the last decades, many of these techniques have come to new use in order to reduce or eliminate mechanical ventilation and cooling, and to reduce the demand for artificial lighting. However, users of today require higher standards for comfort and indoor air quality, and buildings have more complex functions and equipment. Uncritical copying of the passive techniques used in old buildings is therefore not recommendable.

Passive solutions are more sensitive to the external environment (solar load, temperature, wind, etc.) than conventional mechanical solutions. If the potential in passive solutions with dynamic (time varying) behaviour like night cooling, thermal mass and high ceilings is to be utilised, smart control strategies are required.

Advanced computerised control systems, BEMS (building energy management systems), enable control and optimisation of passive techniques in order to utilise the energy saving potential without reducing thermal comfort or indoor air quality. One issue to be resolved is when control of indoor temperature, ventilation and lighting is to be automated and when to be managed by the occupants.

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Sustainability According to Whom? International Viewpoints on Sustainable Design and Development

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The western, US view of sustainability is focused largely on maintaining a very high quality of life while reducing energy, material and resource consumption to more "acceptable" levels. Core issues include limiting sprawl, minimizing waste, and constructing high performance, green buildings using advanced analysis tools, high tech building systems, and construction techniques. The steady growth of the US Green Building Council and formal recognition of the importance of sustainable design and development by the American Institute of Architects, the Urban Land Institute, and several agencies within Federal, state and local government sectors bodes well for the trend continuing. The emerging body of literature and increasing number of successful case studies of singular green buildings and large scale sustainable developments has sent positive messages to private interests, from school boards to Fortune 500 companies. Those who view real estate as part of their investment portfolio are becoming cognizant of the long term benefits of high performance architecture. In the business world, the decision to pursue sustainable design is still largely based on return on investment. Sustainable design and development is making the argument that environmental stewardship and economic opportunity can be mutually obtainable goals. This awareness is not lost on companies who seek the public relations benefit of aligning with the environmental movement. Others are equally and genuinely concerned with the impact of the built environment on building occupants and the natural world. Each is contributing to the inventory of more environmentally sensitive projects. While these efforts are notable for their potential to reduce environmental damage and our dependence on foreign oil, they alone will not change our posture as the world's largest consumer of global resources. And it is the rate and amount of resources we consume that is the foundation of our high standard of living and our quality of life, real or perceived.

In other parts of the world, sustainability is a matter of making it to the next day. Dreams of a high standard of living are as close as the internet for anyone who can communicate with the world electronically; or desperately far away for anyone without food, clothing or shelter. So the question becomes, "sustainability according to whom?" What defines sustainability as circumstances vary, cultures evolve, populations increase, and the worlds dwindling resources continue to serve the privileged few? This paper examines the efforts of several individuals who are determined to use sustainable design and development to make a difference and improve their world; champions of sustainability whose efforts are noteworthy if not genuinely heroic.

In the Czech Republic, Vita is making a difference. Founded soon after the Velvet Revolution of 1989, Vita is one of the first nonprofit organizations to emerge in central Europe. "Vita" means "life" in Czech. Zdenek Jakuba and his wife Vera gave their new organization the name because they wanted to revere life in all its forms, and use environmental causes to breathe new life into their heavily polluted and financially depressed community. Vita was started in the early 1990s

in Ostrava, a center for steel, chemicals and heavy industry in the eastern Czech Republic exploited by the Communists since the end of World War II. They have sought to engage community residents in volunteer efforts and public education campaigns which use the tenets of sustainable design and development to improve core community organizations. Early efforts were self funded environmental education projects in elementary schools, using Zdenek's skills as a teacher and environmentalist. Vita was soon recognized as an organization capable of



Zdenek leading a community meeting



The community building a playground

organizing the community and overcoming years of skepticism brought on by the previous occupation. This caught the attention of the Central European Linkages Project, a US effort supported by the Heinz Endowments, and the Rockefeller Brothers Foundation. An alliance was formed to enable Zdenek to expand his work in designing ecologically based playgrounds in schools and daycare centers. The author was engaged as Director of Green Building Services for Conservation Consultants Inc., a non profit organization based in Pittsburgh, PA. Ann Gerace, Executive Director of Conservation Consultants, is credited with using the Pittsburgh Green Neighborhood Initiative as a model to assist Vita in expanding its mission. I was able to lend my expertise as an architect and sustainable design consultant specializing in permaculture. The project has been in continuous development since 1996. Several playgrounds based on permaculture design and plant based site features have been designed and constructed in communities around the Czech Republic. In each case the community is involved in a series of meetings and charrettes. All building materials are found naturally in the environment, and are obtained locally, often donated by the community. All labor is volunteered, with Vita providing project management. The results are ecologically sound, safe, and beautiful play environments that teach children about the natural world. The adjacency of the playgrounds to schools and daycare centers serve to introduce other teachers and administrators about sustainable design and environmental education. Vita has used its success to expand its mission into weatherizing residences and community gather places such as the local sporting club. It is participating in environmental awareness conferences and sponsoring a growing number of workshops to educate a growing community to the benefits of energy conservation, pollution reduction, and living better sustainably. The Czech Republic is a better place because of Vita.

In a one hundred day period in the spring of 1994, in genocide unprecedented in African history, the Hutu faction of Rwandan society massacred over 800,000 Tutsis. In his best selling book *We wish to inform you that tomorrow we will be killed with our families – Stories from Rwanda,* Philip Gourevitch attempts to explain the history and cultural disintegration that led to these horrific events. He also chronicles the years immediately following, the lingering effects of

refugee migrations, and the civil strife that made healing the economic and societal devastation caused by the genocide impossible. And while my western brain will never fully understand the events that occurred that spring, it is against this backdrop that new efforts have begun to address certain aspects of development in Rwanda. It is a place where a dignified existence is possible, if the cultural and warring factions would permit peaceful coexistence. Rwanda is also a place where several international organizations have focused relief efforts. My involvement in sustainable design and development efforts happened through the presence of the Episcopal Diocese of Pittsburgh, which has mission ties with the local Episcopal Diocese in Kigali and Ruhengeri. The Episcopal Diocese includes environmental stewardship as part of its mission.



Making bricks…



for Sun Rise School

But the real story of sustainable design and develop is that of Kiengo, an architect trained in the Congo, who is sympathetic to environmental issues and who has supported the efforts of the Dioceses. He single handedly designed the Sun Rise School, on one sheet of 24" x 36" paper, to be constructed by members of the Hutu and Tutsi communities in the Ruhengeri region. His idea was to supervise the construction of the school using alternating shifts of people involved in the previous conflict, until they could eventually be brought back together. In order to use the building to instruct, he planned the sequence of construction in week long sessions, with volunteer labor mixing with paid local craftsman, working to predetermined brick coursing distinguished by colors. This was done because most of the workers could not read or write. The excavation, concrete mixing and placement was done by hand. The brick was mined and fired locally. The trusses were fabricated of recycled wood on site with hand tools. Metal for the roofs, some of which was recycled from structures burned or otherwise damaged in the genocide, was obtained from relief agencies and local retail suppliers. All of the furniture was manufactured by local craftsmen. The result is a stunning example of the best attributes of sustainable design; the ability of architecture to be restorative. Kiengo's vision is now manifest in a beautiful energy, material and resource efficient school where the survivors of a horrific event in human history may someday learn about the world and how to live peacefully together.

When Gwen and Larimer Mellon decided to trade a life of comfort and security underwritten by the Mellon family fortune for a life of service to mankind, they looked for the poorest place on earth with the greatest number of people in need. Inspired by the work of Dr. Albert Schweitzer in the Gabon, and the African Congo, the Mellons set forth to establish a hospital where treatment would be based on need, and the ability to pay would be secondary to the desire to

improve the human condition. Dr. Schweitzer was already in Africa. The Mellons decided on Haiti, now the poorest country in the Western Hemisphere, and the site of ongoing political corruption, environmental degradation, and rampant disease. Haiti has suffered the ravages of colonialism, and the slave trade. It has been transformed from a tropical paradise to an ecological and environmental disaster through unregulated extractive industries and unchecked pollution, much of which happened in concert with the design, construction and operation of Hopital Albert Schweitzer (HAS) by Gwen and Dr. Larimer Mellon since its beginning in 1950.



Mother and child at Hopital Albert Schweitzer



Installing a Photovoltaic Array

Today a team of architects and consultants led by Luke Desmone, AIA, has undertaken the task of working with the administration and staff of HAS to construct a sustainable design and development master plan. The intent is to modernize and rejuvenate the fifty two year old facility which has begun to suffer from increasing case loads and dwindling resources. Charrettes have been held on site to gather information and include the community, staff and local expertise. The design calls for the renovation of existing buildings left by the previous plantation owners to work better with natural ventilation, daylight and appropriate technologies for the generation of electricity. Efforts are underway to wean the facility off the diesel generators by involving more photovoltaic power and wind generators. A permaculture plan is being integrated into the design to harvest the top soil and nutrients that have occluded the surface storm water channels and irrigation canals. Rain water harvesting is being brought back into the design in response to increasing water demand and decreasing availability. Water quality is also a growing concern as the existing sewage fields experience more frequent failures. The design of new housing seeks to remedy chronic pest infestation, while providing a modicum of creature comforts and respite from the highly stressed work environment. New housing and administration buildings will reflect the best practices of the tropical vernacular. All of this is being accomplished through fund raising and in kind support from the HAS organization. In the end, sustainable design and development will enable Hopital Albert Schweitzer to extend the vision of Gwen and Larimer Mellon to future generations.

The Ministry of Construction in China reports that 1.7 billion square meters of construction took place in Chinese municipalities in 1997. It predicts that 6.7 billion square meters of new construction will be completed in 2005. As China braces for what it is calling the Green Olympics in 2008, the world is watching how the most populace nation on earth will deal with the development issues before it. In Shanghai, a city the size of Chicago with four times the

population, development is everywhere. Every year, an urban area the equivalent of Harlem is being torn down and rebuilt. Several new cities are under construction. The Three Gorges hydroelectric dam project, one of the largest in the world, is controversial because of its mixed blessing of increased power supply and extensive environmental damage.

There is growing interest in sustainable deign and development in China for several reasons. First, the Chinese must do a better job of energy and resource efficiency if it to meet the growing demands of its population. Second, sustainable design and development will be necessary to balance development with impacts on the environment. China suffers from severe air pollution, water supply shortages and poor water quality. Industrial pollution remains unchecked in some areas, despite government directives to move polluting industries outside urban areas. Municipal waste treatment problems abound. In spite of all of this a Chinese citizen consumes $1/14^{th}$ the resources of a typical American. And, a Chinese citizen is responsible for less carbon production per capita than their US counterpart.



New high rise buildings in Shanghai



Old neighborhoods being demolished

The promise for sustainable design and development in China is held by a variety of stakeholders. Tongji University, working in conjunction with the Asia Pacific Institute, has begun a number of sustainable design initiatives. The Olympics are expected to showcase a number of green design approaches to venue design, housing, transportation and related services. Private developers are beginning to incorporate sustainable design and development techniques in a variety of projects. China has expressed an interest in working with the USGBC to promote sustainable design. The author is personally involved in several development projects that are using the US Green Building Council's Leadership in Energy and Environmental Design (LEED™) building rating system as a design guide. These include the Tiandu Sales Center, Jiangdu Gardens, and a twenty six story high rise in Harbin.

How sustainable design and development will impact China remains to be seen. Clearly, anything but sustainable design and development will have dire consequences on an already stressed planet.

All of the people involved in the work contained in this paper have different views of what constitutes sustainable design and development. History, recent events, cultural differences, geography, socio-economic differences and geopolitical realities have brought them all to very different places in the same span of time. Each has different goals and expectations. In the Czech Republic, sustainable design and development includes community involvement and a

sense of what constitutes a better place. Vita's green neighborhood initiative translates to "a better place to live." In Rwanda, villagers in a region who will probably never experience the comforts of the western world labor through uncertain circumstances to build a school that will serve as the center of a new community; one that will hopefully lift them beyond the horrors of the past. In that new community sustainability will be a reflection of tolerance for one another. The administration and staff of Hopital Albert Schweitzer look to the tenets of sustainable design and development to breath new life into an aging medical facility that some believe should be classified as a world heritage site. Lessons learned from the life of Gwen and Larimer Mellon resonate with the foundations of sustainability when we discover how much was accomplished with so little, and how many have benefited from the dedication of so few. It is doubtful whether the work will ever be formally recognized by any green building rating system; the registration fee is better spent on medicine and care for the chronically ill. And sustainable design and development takes on enormous importance in China and the rest of Asia as we realize that if everyone would live at the standards enjoyed by the US, it would take four planets to support the existence of everyone expecting the same.

It has been a great privilege for me to travel the world and participate in the work discussed herein. The people I have worked with have become my heroes, and remain my friends. They have influenced my thinking, and enriched my life. Most of all, they have caused me to reconsider the life I have enjoyed, and the values I have formed. They have taught me what it means to be sustainable, how to participate in restoring the planet, and to live in peace. And for that I am most grateful.

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Searching for the Improvement of an Energy-Efficient House in Montreal

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ABSTRACT
This paper presents the search for the improvement of a sustainable house, built in year 2000 in Montreal, Canada using the multi-attribute analysis during the life span of the building. Although the base-case house is energy efficient, results show that there is still significant potential for increasing the energy efficiency. Cost effective alternatives are recommended for the selection of materials and design of houses in Canada to be considered in the future by architects and engineers.

BUILDING DESCRIPTION
The case study house consists of two apartments, the owner apartment including the basement and ground floor, and the tenant apartment on the second floor. The total built-up area is 310 m^2, which is almost divided equally among the three floors. The designer has opted for the north-south direction, with open space facing south, for the house location. The living and dining rooms are arranged to the south facade to favor the period of sunshine in winter, whereas the night-spaces such as bedrooms are placed to the northward (Figure 1). Maximizing the glazing area of the southern facade and minimizing it on the other facades was one of energy-efficient approaches used to increase the heating solar gains. Glass fiber framed windows with double-glazed sealed units with low-emissivity and filled with argon gas were installed; the thermal resistance of the windows was 0.57 $W/m^2.^oC$. The exterior walls above ground were constructed using 38x140 mm wood studs with 128 mm thick blown-in cellulose. On the exterior side of the wood studs, horizontal 38 mm x 38 mm furring strips were installed and covered with an exterior sheathing. A sprayed in-situ polyurethane insulation filled the space between the sheathing and the wood studs to minimize the thermal bridges, increase the thermal resistance of the assembly and provide a continuous airtight assembly. A well-sealed 6 mm vapor barrier was used to control vapor transport and to seal the wall against air leakages. The total thermal resistance for the basement walls, above ground walls and the attic was 4.4, 5.43 and 10.87 $W/m^2.^oC$ respectively, which exceed the minimum requirements by the energy-related regulations of the province of Quebec [1].

Table 1. Thermal resistance of the base-case house envelope vs. Quebec regulations

Components of the building envelope	Thermal resistance [$W/m^2.^oC$]	
	Base case house	Quebec regulations
Roof or attic	10.87	5.3
Walls above ground level	5.43	3.4
Walls below ground level (basement walls)	4.4	2.2
Exterior windows	0.57	0.35

The blower door test revealed that the air infiltration rate at 50 Pa is equal to 1.25 ach, which is less than the requirements of R-2000 energy-efficient house of 1.5 ach (built according to specifications developed by Natural Resources Canada). Figure 1 presents the ground and first floor plans of the base case house; the basement design is similar to the ground floor:

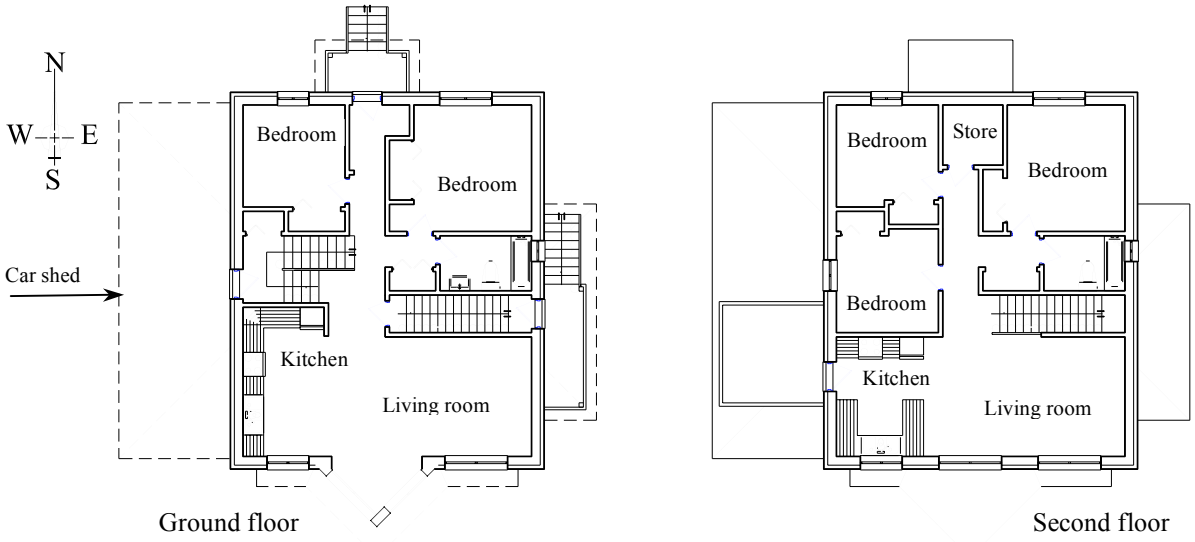

Figure 1. Ground and second floor plans of the base case house

The computer model of the house was developed by using BLAST program [2] and on-site measurements such as air leakage based on blower door test. Then, the computer model was calibrated using the short-term monitoring of indoor air temperature and the energy consumption contained in the utility bills for year 2000. Only the heating season was simulated from October 1st to April 30th. The simulation results for the calibrated computer model indicated that the annual heating consumption of the house is 10,470 kWh or 34 kWh/m^2 yr. The embodied energy of the house, except plumbing, electrical and HVAC systems was estimated at 196,630 kWh, which equals 19 years of heating.

DESIGN ALTERNATIVES

Several design alternatives have been developed and their performance was evaluated using the calibrated computer mode. The design alternatives comprised the following:

1- Modifications of the characteristics of building envelope including: (i) thermal resistance of exterior walls, roof and windows; (ii) thermal mass of interior and exterior walls; (iii) airtightness; (iv) solar absorptivity of exterior surface of walls; and (v) installation of movable insulation on windows.
2- Modifications of the architectural design comprising: (i) building form; (ii) glazing-to-wall ratio; (iii) house orientation; and (iv) presence of close or attached buildings.

Five values were set for each design alternative: a minimum value, a maximum value, and three intermediate values. When one parameter was modified, the rest of variables held the values corresponding to the base case design. Some examples are presented below.

Variations for the House Orientation

The base-case house is built along the north-south direction. The impact of the house orientation on the energy consumption of the base case was investigated by rotating the house between –90° to +90° (Figure 3). As expected, the best rotation angle is 0°, which indicates the north-south direction. However, when the house changes the orientation within -30° and 30° from south, there is a negligible increase, of less than 2% in the annual energy consumption.

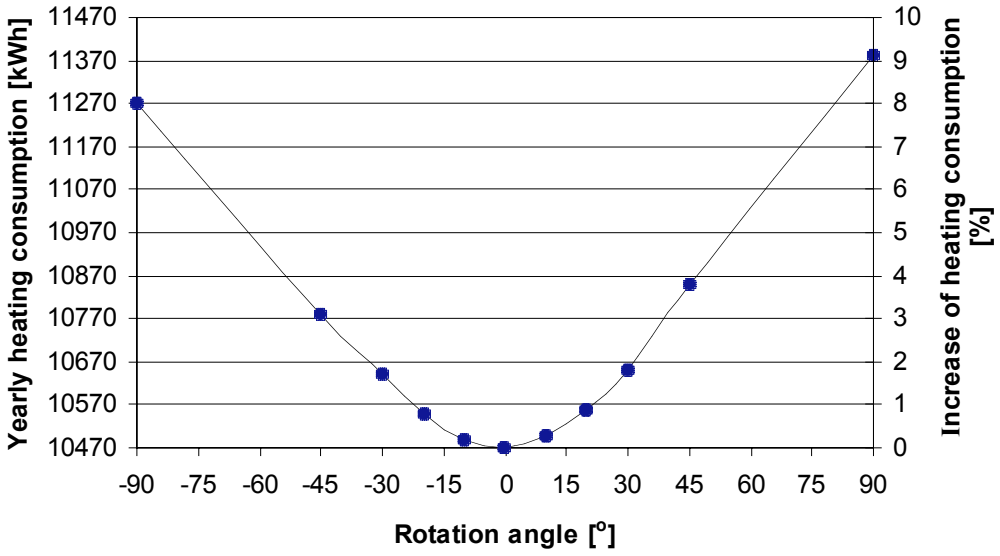

Figure 3. Yearly heating consumption versus rotation angle

Modifications of the Thermal Resistance of Exterior Envelope

Five values were proposed for the thermal resistance, creating five alternatives for the basement walls, above ground walls and the attic. For instance, the minimum value for the above ground walls was 3.4 W/m^2.°C, which coincides with the minimum requirements of Quebec regulations [1], while the maximum value was 10.57 W/m^2.°C. This value was selected based on a study of a hyper-insulated house in Saskatchewan, Canada [3]. Three intermediate values were selected: 4.4; 5.4 (base-case); and 7.9 W/m^2.°C.

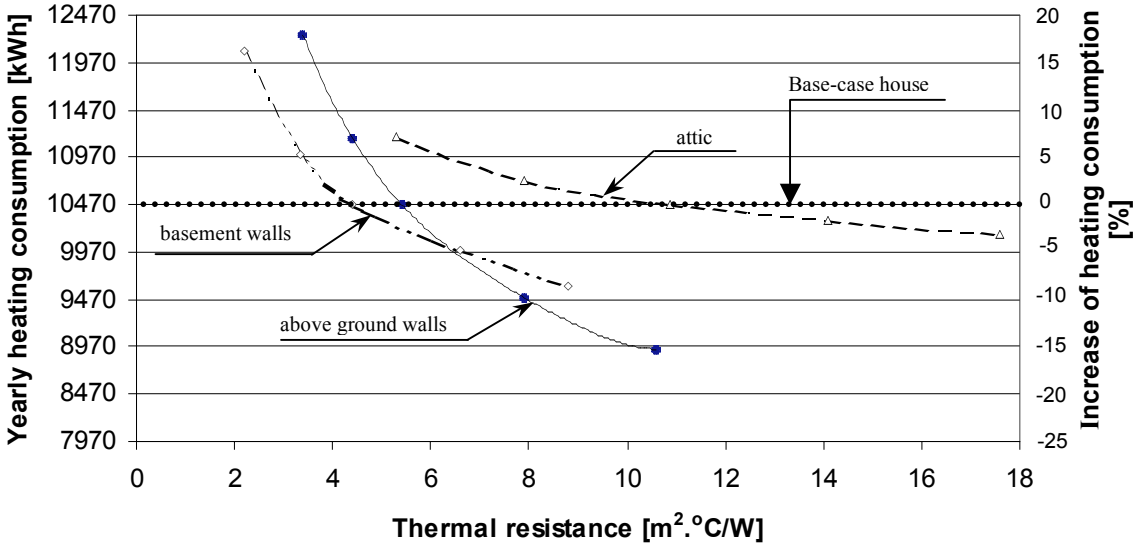

Figure 4. Yearly heating consumption versus thermal resistance of exterior envelope

Results (Figure 4) show that the increase of the thermal resistance of exterior envelope led to considerable reduction of the heating consumption. For instance, a reduction of about 14.6% of heating energy was noticed when the maximum value of 10.57 W/m^2.°C was used for the above ground walls. Furthermore, the maximum values of 8.8; 10.57; and 17.6 for the basement walls; above ground walls and the attic, respectively, were combined in one alternative; a reduction of about 25.7% for heating energy was estimated for such alternative.

Modifications of Glazing-to-Wall Ratio

The glazing-to-wall ratio of the base case is about 11% for north facade; 1% for east facade; 2% for west facade and 30% for south facade. For each facade, the minimum and maximum values were selected based on architectural and structural design. For instance, the minimum value for the south facade was set at 0%, while the maximum value was set at 60%. Three intermediate values were selected: 15%, 30% (base case), and 45%. Results (Figure 2) reveal that the increase of south facing glazing led to a considerable reduction of heating consumption with respect to base case house, e.g. using 60% of glazing at southern facade led to a reduction of 8.5% of annual heating. On the other hand, increasing the glazing areas of the other facades led to an increase of heating consumption.

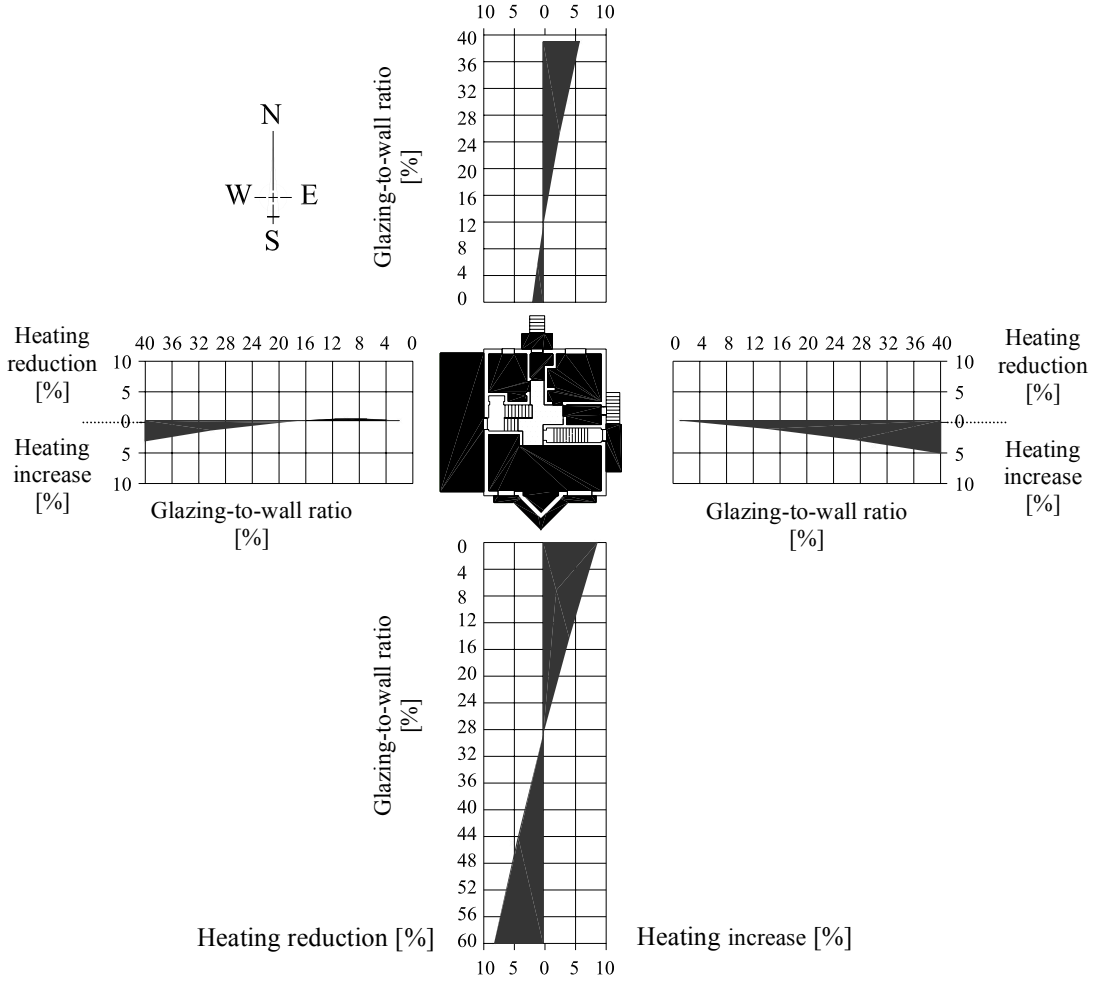

Figure 2. Impact of glazing-to-wall ratio on the heating consumption of the base case

EVALUATION OF DESIGN ALTERNATIVES

The evaluation of design alternatives is based on the life-cycle analysis (LCA) using the following three criteria:

1- Life-cycle energy including: (i) the embodied energy of building materials calculated by ATHENA software program [4]; and (ii) the operating energy calculated by BLAST program.

2- Life-cycle cost comprising: (i) the cost of building materials from MEANS Cost Data; and (ii) the heating energy cost during the life-cycle of the building calculated with electricity rates of Hydro Quebec (CAN$ 0.0584/ kWh). The present worth factor was used to calculate the present value of heating cost over the life cycle, assuming that the life cycle of the house is 30 years; interest rate including inflation is 5% and the energy escalation rate is 0%.

3- The environmental impact calculated in terms of equivalent CO_2 emissions by utilizing the Global Warming Potential (GWP) index [5]. In Quebec the hydro-electricity accounts for about 97% of electricity used in the residential sector. It is assumed that hydro-electricity does not generate greenhouse gases. In this study, it was assumed that heating oil and natural gas account for 3% of heating consumption and the hydro-electricity accounts for 97%. It was also assumed that 100% of embodied energy came from oil and natural gas. Results show that four parameters (Table 2) have a significant impact on the base-case house:

Table 2. Design alternatives with highest impact on energy consumption of the house

Parameters	Abbreviation	Heating consumption [kWh/ year]	Heating reduction [%]
Base-case house		10 470	0
Thermal resistance of basement, ground and first floor walls, and roof: 8.8, 10.57, 17.61 [$m^2.^oC/W$]	R	7 775	25.7
Airtightness: 0.60 [ach]	A	8 612	17.8
Thermal resistance of windows: 0.88 [$m^2.^oC/W$]	W	9 366	10.5
Glazing-to-wall ratio for house facades [%]: (north= 0.0); (East= 1); (west= 2); and (south= 60)	G	9 455	9.7

Combinations between the optimum design alternatives (Table 2) were proposed, first in pairs, then in groups of three and finally all the four parameters. The Life-Cycle Analysis (LCA) approach was used to estimate the overall impact of such alternatives. For the selection of the best design alternatives based on LCA approach, the normalized score [6] was used. Due to the difference in units of cost ($), energy (kWh) and equivalent CO_2 emissions (kg), the normalized scale, from 0 to 1, was used for the life-cycle energy (N_{kWh}); life-cycle cost ($N_{\$}$); and equivalent CO_2 emissions (N_{co2}). For instance, the normalized scale of life-cycle cost ($N_{\$}$) is determined by:

$$N_{\$} = (C_a - C_{min})/ (C_{max} - C_{min}) \quad (1)$$

C_a is the life-cycle cost for alternative a ($); and C_{min} and C_{max} are the minimum and maximum values of life-cycle cost ($), respectively, with respect to all alternatives. Then the normalized score is established for each alternative by:

$$\text{Normalized score} = W_1 (N_{\$}) + W_2 (N_{kWh}) + W_3 (N_{co2}) \quad (2)$$

W_1, W_2 and W_3 are weighting factors used for evaluating the impact of life-cycle energy use; life-cycle cost; and equivalent CO_2 emissions, respectively on the LCA of design alternatives.

In the following example (Figure 5), equal weights were used. The design alternative of the glazing-to-wall ratio (Table 2) was combined with other alternatives. Results show that the best alternative is G&W (Figure 5), which has a combination between the alternative of the thermal resistance for windows (0.88 $m^2.^oC/W$) and the alternative of the glazing-to-wall ratio (north= 0.0%; east= 1%; west= 2%; and south= 60%). Although other alternatives consume less energy than this alternative, the impact of their life-cycle cost and equivalent CO_2 emissions on the house is greater.

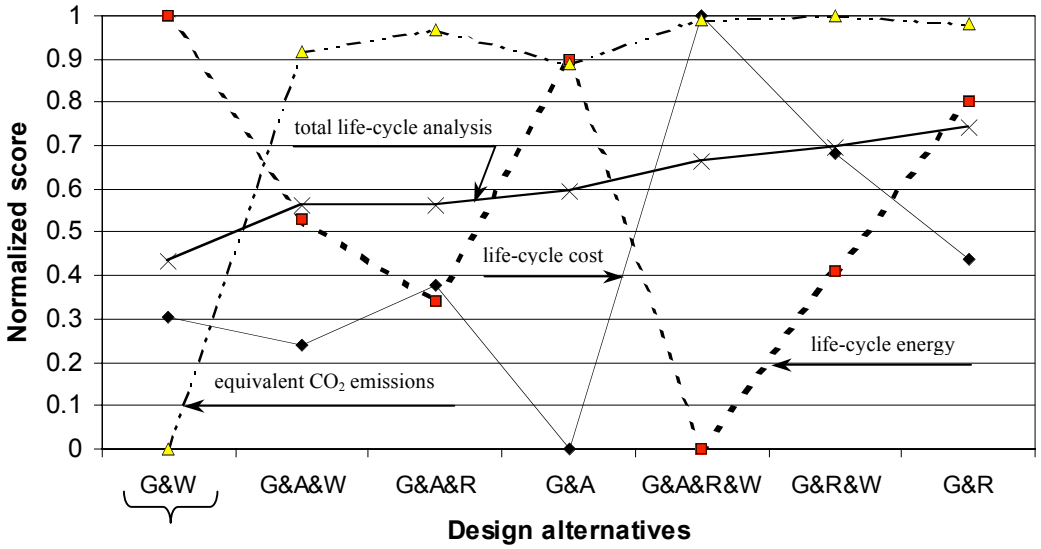

Figure 5. Life-Cycle Analysis of the glazing-to-wall ratio alternatives

CONCLUSIONS

Results show that there is still a potential to improve the energy performance of this house, which is already energy-efficient. Most of design alternatives have a significant impact on the operating energy consumption of the house. Four parameters were investigated and recommended for the optimum energy-efficient design: thermal resistance (insulation) of building envelope; infiltration rate; thermal properties of windows; and glazing-to-wall ratio. The combination between the best alternatives for such parameters led to significant reduction of the energy consumption. Although some alternatives consumed less energy than others (Figure 5), they were not effective whenever the overall impact of cost and equivalent CO_2 emissions were considered. Therefore the multi-attribute analysis approach is essential for evaluating the energy-efficient design of buildings.

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Sustainable building, ECN 31 and 42 - Petten (NL)

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1. INTRODUCTION

1.1 Aim of the project

The aim of the project is to construct energy-efficient and sustainable buildings and demonstrate the use of renewables in the built environment. Both, the retrofit of building 31 and the new office- and laboratory building 42 of the Netherlands Energy Research Foundation ECN in Petten are a demonstration of these aims.
The projects are supported by EU Thermie, NOVEM and the utility NUON.
In order to make PV more economical, PV integration in buildings is an option that may save money on supporting systems, savings in roofing materials, and savings in floor space.



Figure 1 ECN buildings 42 (left) and 31 (right).

2. APPROACH

2.1 ECN Petten

The buildings are located at the site of he Netherlands Energy Research Foundation ECN in Petten, the Netherlands. ECN is attractively situated in the dunes in the Northern part of Holland, close to the village of Petten.

2.2 Building 31

In 1997 the ECN unit for 'Renewable Energy in the Built Environment' made a study to evaluate the building condition of laboratory building 31 as well as facts of energy consumption. The survey showed that the existing building (constructed in 1963) has several major technical and thermal shortcomings, which will be taken care of in the renovation process.

Table 1 Problems of laboratory building 31.

Building 31 had several technical and thermal problems:
bad insulation of the envelope and thermal bridges;
overheating in mid summer; inefficient lighting system;
high rate ventilation system for the laboratories with low efficiency and comfort;
high heating and electricity demand;
facade in bad condition led to draught due to thermal bridges;
draught, due to ventilation system and badly distributed heat.

For the laboratory 31 a PV-integrated shading system have been designed. The project is a co-operation between ECN, BEAR Architecten, utility NUON, Shell Solar Energy and the Italian architect Cinzia Abbate (Rome). The Danish manufacturer Dasolas/Alco is involved in producing the combined PV support / sun shading system.



Figure 2 Integration of PV in solar shading (building 31)

To prevent overheating during summertime, the south façade has been provided with sunshades. PV modules have been integrated in this shading system. To optimise solar gain there needs to be a certain distance between the lamellas of the system. For fine tuning the shading system, a simple second system is placed on the inside. Furthermore, the shading system diffuses the daylight and the structure allows easy access to the façade for building maintenance and window cleaning.

A PV roofing system has been designed and installed in co-operation with BP Solar. The installed capacity of the system is approx. 35 kWp.
When the building renovation is completed, the primary energy demand will be reduced with 75%. The amount of PV that will be applied is about 72 kWp : 50% integrated in the façade and 50% at the roof. All together the PV system will produce about 56,440 kWh per year.
The renovation project is part of the EC Thermie program (SE 0115/97/NL/DK) and financially supported by the EC. The project is constructed in the years 2000-2001.

2.3 Building 42
The office building 42 consists of three building units. The construction of the first unit is finished in March 2001. The other unit's will be built in the next years.



Figure 3 The corridor between the buildings.

The building has been designed to maximise the use of daylight and to minimise the use of artificial light. To accomplish this the structure of the building is compact and the building has several atriums allowing a maximum use of daylight. All working places are situated in the daylight zone near the facade. The glass-covered corridor on the first floor, with its entrances to the office-units, will be the connecting element between the building. The use of photovoltaic cells in the curved glass roof and a lot of natural ventilation prevent overheating in the summer. The 43 kWp PV system is installed by BP Solar.

Table 2 Options realized in building 42

Realized options for building 42:
compact building form;
high insulation values for floor, roof, windows and facades;
unheated corridor (conservatory) space as a climatic buffer;
reduction of cooling load by the ventilated corridor with PV glazing (parasol idea);
daylight controlled artificial lighting system;
ventilation concept with heat recovery system;
natural summer night ventilation by automatic opening windows;
optimized daylight through the corridor and atrium;
air-heating system to cover the low demand.

3. THE PV SYSTEM

3.1 Building 31, the façade

The building had a problem of overheating in summer. An outer sunshading system was necessary. It was clear that the PV modules should be integrated in the sunshading system. Such a solution may:

- give good shading of the building in summer;
- optimize solar gain;
- diffuses daylight;
- give easy access for maintenance of the building and cleaning of the windows (maintenance walkway).

Besides there is more than one reason that justifies the use of integrated PV modules in the shading device: construction costs will be optimized by the elimination of costs of a conventional PV module support system; interior light and temperature will be improved and energy is produced directly where needed.

The choice should be made whether the shading device should be mounted close to the facade or at a certain distance. Furthermore, the size of the lamellas had to be discussed: should a few, wide lamellas be chosen or a larger number of slim ones? What should be the length of the lamellas?

From the point of view of maintenance, accessibility and window cleaning it was decided to have the shading/PV device constructed as a separate facade, about 80 cm from the building, connected to the main structure of the building. The length of the lamellas followed from the building structure grid.

In order to make a choice for the width of the lamellas various solutions for an integrated system were examined:

- two large lamellas with modules, at a vertical distance of 1.5 m in a fixed position;
- idem with moveable tracking system;
- seven small lamellas with modules, at a vertical distance of 0.5 m in a fixed position;
- idem with moveable tracking system.

The study was carried out with a model of a laboratory room scale 1:10 in a daylight chamber and on a solar table. It focused on the solar gain, the heat load of the building, shading of the building, shading of the modules, outside view from the interior and daylight conditions. This study showed, that the best results for solar gain, shading and daylight were obtained with a model using 4 fixed lamellas per floor. Considering the solar ratio between a fixed vertical system and a moveable vertical system, the solar gain is only approximately 10% higher with a moveable one.

Considering the high costs of a moveable system compared to a fixed structure, and the small difference of solar gain it was decided to select a system that is fixed in the optimal position (in the Netherlands 37° with the horizon). However, the occupant of the rooms behind can move one lamella, at eye level, in a horizontal position, in order to have a good outside view. After a defined space of time, for instance 20 minutes or so, the lamella will automatically take its position of 37° again. Thus, a continuously varying architectural view is created.

Each lamella will be about 840 mm wide, 3000 mm long and will be covered by three standard multi-crystalline PV modules on the front part. Because of the dimensions of the lamellas the building is shaded during the summer period. The efficiency of the shading system is about 85%. For fine-tuning the glare, especially in winter, a second, very simple interior shading system is provided.

Because of the new exterior PV/shading system overheating of the south facade will be avoided and an expensive, energy consuming, air-conditioning system is not necessary.

As far as can be predicted from the study, the specific position of the lamellas might improve the distribution of the daylight in the rooms compared to the existing situation. The daylight situation through the rooms might be more equal. However, to be sure about the effect of the integrated PV/sunshading system on the delighting of the rooms behind, a separate study is carried out. This study, consists of advanced daylight computer simulations. After evaluation of the results a mock-up has been built, followed by measurements. But not only daylight aspects are examined by means of the mock-up. Also constructive implications, deterioration of moveable construction parts, questions of manufacturing, colour and acceptance by the users of the building are examined in the prototype stage. By spending time and money for the prototype, mistakes are avoided in the construction phase.

3.2 Building 31, the roofing system

The PV roofing system was originally meant as a kind of a parasol, a passive-cooling device for the roof. The roof construction underneath should provide water tightness. As the design of the interior of the building got more and more shape, it became clear that the space between the parasol and the existing roof should be used for technical installations. So it was decided to construct the parasol as a watertight part of the building.



Figure 4 The roof of building 31

3.3 Building 42

Special emphasis has been given to architectural and constructional aspects of integrating the PV modules in the building.
The glass-covered corridor on the first floor, with its entrances to the office-modules, is the connecting element between building 31 and building 42. In the roof of this unheated and strongly ventilated conservatory, PV modules are integrated. The transparent modules have a 2 centimetres free space between the cells. Thus providing daylight in the conservatory. In this way the use of photovoltaic in the curved glass roof prevents overheating in summer and provides diffuse daylight. The glass roof is like a parasol for the building under it.

4. SCIENTIFIC INNOVATION AND RELEVANCE

The scientific innovation and relevance of the project are high. The PV system is architecturally integrated in the buildings. The use of solar energy had an important role in the design process. The project shows how new sustainable concepts enriches the architectural value of buildings.

The interest in the project, both from national and international sides, is large. Thus the project may encourage the application of PV systems. The innovative constructions for PV integration in the roofs and in the facade contributes highly to the reduction of heat load of these buildings. Thus, energy consuming air-condition equipment is avoided.
The project is regarded as innovative because of its contribution to new developments in the sun shading industry, the architectural solution, the integration of PV, shading, passive cooling and daylight, the good outside view by moveable lamellas and the good inside view by diffuse lighting. Integration of PV systems in shading devices or in atriums can result in considerable cost reduction.

5. RESULTS / CONCLUSIONS

By integrating PV systems in buildings, a better quality/cost ratio will be attained. The architectural integration has a high relevance. These buildings are a good example of building integration of photovoltaic. The concept of the new building has good potentialities to fit all kind of alternating organisations in the future.

6. PARTNERS

Architectural design: BEAR architecten, Gouda, the Netherlands
Co-operating designer solar shading: Cynzia Abate, Rome, Italy
PV systems: Shell Solar Energy, Amsterdam, the Netherlands and BP Solar, Amsterdam, the Netherlands / London, United Kingdom
Principal: ECN, Petten, the Netherlands
Structural designer: Van Heugten Nijmegen, the Netherlands
Supplier solar shading: Dasolas / Alco, Kopenhagen, Danmark; Zaltbommel, the Netherlands

‘Le Donjon’, WWF ‘Panda’ office with PV-canopy - Gouda (NL)

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1. INTRODUCTION

1.1 The ‘Le Donjon’ office building

The building is located in Gouda, between a residential neighbourhood from the thirties with two story brick homes and a railroad. Town planning regulations and building codes strictly asked for integration of the new building in this built environment. Three investors own the three buildings, which are grouped around a courtyard.



Figure 1 Office building ‘Le Donjon’

1.2 Aim of the project

The building owned and used by BEAR Architecten is different from the other buildings for its technical installations. The aim of the project has been to realize an energy-efficient office building and the possibility to integrate solar energy. Passive, thermal and photovoltaic solar energy has been used. Passive solar is gained by large south facing windows. A thermal solar panel is in use for the hot water supply (dishwasher and cleaning).
The PV system is designed as a PV canopy roof on top of the walls and will protect the top of the walls against rain. This function meets the sustainable building code 'DuBo S061' in the Netherlands: “protect the walls by adequate façade design”. Further aims of the project are an aesthetic but relatively cost efficient mounting construction for the PV-system - compared with other façade or roof integrated systems. These purposes fits the purpose of the building project: The realization of an energy-efficient office building within an average budget (conform the real estate market).
A second 3 kWp system (new product development) is placed on the roof.

2. APPROACH

2.1 Low energy

The three buildings have the same building construction but each unit has its own installations and specific climate control system.
A basic low energy design is made for all three the office buildings. This includes a well-isolated envelope, the use of passive solar energy and the use of environmentally friendly building materials (with low embodied energy).
The building owned and used by BEAR Architecten has further environmental measurements. The energy measurements in this building part are: two PV-systems (6.2 kWp and 3.0 kWp); a small thermal collector (ca. 2.5 m^2) for hot water, a high efficiency gas boiler; a radiant floor heating system for office spaces and low temperature radiators for the meeting rooms; balanced ventilation with heat recovery system (winter); summer-night ventilation for cooling; building management system; daylight controlled and energy saving HF (high frequency) lighting; light tubes with daylight spectrum (Truelight); electricity saving equipment such as flat screens, low energy (A-class) fridge and dishwasher; switches for each working place, to avoid standby losses of computers. The Energy Performance Ratio (EPc) of this building is 0,6 (exclusive of the 3.0 kWp new PV system). This is 40% of the requirements from the building code (maximum EPc of 1,6).
Concerning building materials, in the building we used natural materials as (FSC) wood, natural paint and linoleum. But also materials like recycled aluminium.

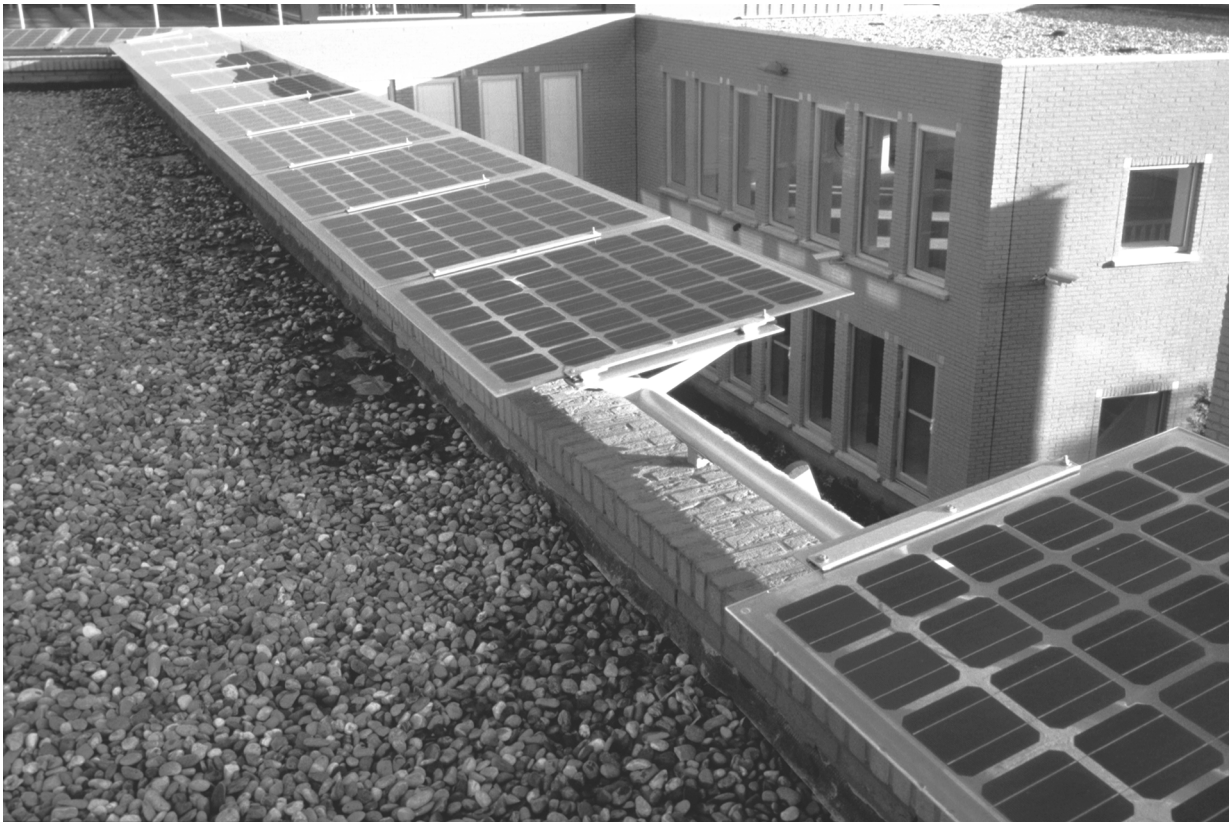

Figure 2 The PV canopy

Other sustainable issues are: water saving installations and rain water use for toilet flushing; rain water pond for slowed down rain water discharge and roof-garden; nesting boxes for bats and swifts.

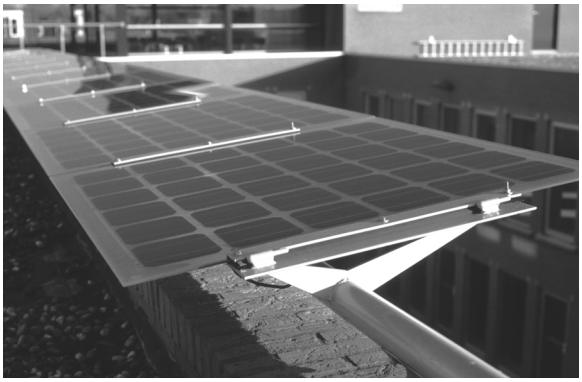

Figure 3 Detail of the PV canopy



Figure 4 The new product development second 3 kWp system on the roof

2.2 WWF Panda office

The office of BEAR Architects is sustainable to such an extend, that it has received a WWF Panda-hallmark. In order to obtain this hallmark, the building has to meet the following very stringent requirements:

- the Energy Performance Ratio (EPc) has to be lower than 1.1 (whereas the governmental building code asks for a maximum of 1.6). This building has an EPc = 0.6.

- the capacity of the PV system has to be at least 1 W/m2 (BEAR's capacity is over 10 W/m2);
- the governmental sustainable building codes for utility buildings have to be met;
- only wood with FSC-hallmark for sustainable forestry is allowed;
- all requirements have to be checked by an independent consultant during the design and after the construction of the project.

2.3 Sustainable building

An ecological assessment of the building has been carried out by NIBE (Dutch Institute for Building Biology and Ecology). NIBE used the GreenCalc method to calculated environmental sustainability of the building.

GreenCalc is a computer model, developed by NIBE Consulting for office buildings and other commercial buildings. The programme is divided into four modules: materials, energy, water usage and mobility. The environmental assessment is translated into costs per m^2 for the total life-cycle of the building (construction, exploitation and demolition).
GreenCalc calculates the environmental costs for the materials according to the TWIN-model.

In the GreenCalc calculation the module material is subdivided into raw materials, pollution, waste, environmental nuisance, ecological effect, energy, re-usability, repairability and lifespan. GreenCalc gives a clear view of the environmental cost over the different structural parts of the building and determines the total CO_2-production as a result of the material usage.
The module energy consists of different parameters: building use, heating-, cooling-, ventilation- and hot water system, type of artificial lighting, use of solar energy, etc. These parameters are on itself the base for the Energy performance Ratio (EPc), which is an energy efficiency calculation based on the energy consumption within the building.
The water-module of GreenCalc calculates the effects on water usage. Parameters are the type of sanitary, use of fresh water or the substitution of fresh water by a "grey water" circuit (use of cleaned waste water for toilet flush, garden, etc.).
Mobility looks at the location of the building in relation to its environment, infrastructure, connections and distances to public transportation.
Calculations made with Greencalc v.2.0 give a total score on a scale from 1 - 2000. The average building built in 1990 has a score of 100 and the goal for 2050 is buildings with a score of 2000.

The assessment for this building shows the result of 312 (exclusive of the 3.0 kWp new PV system on the roof).

Early 2001 there are no buildings that have a better score. The highest score was 292 for a building after construction and 817 for a renovation of a building (still in design phase).

3. THE PV SYSTEM (CANOPY)

3.1 Architectural integration

For architectural as well as for economic reasons the PV-system (72,5 m^2) is designed as a multi-functional building element. A study was done to find out the optimal PV system for a flat roof. It was found, that a canopy roof with a low angle (9°) was a good option. This option uses the available light from all directions. The canopies are facing all orientations. It's obvious that the south-facing canopy has a 10% better yield than the north-facing canopy.

3.2 Technical details

The PV-modules are tailor made frameless laminates. The transparent backside foil allows a semitransparent visual appearance.

The system consists of 51 laminates with 111 Wp each and 8 triangular modules with 567 Wp in total, both AP-106 mono crystalline silicon solar cells made by Astro Power. The system is divided into three strings, connected to three inverters(type 'Fronius Sunrise Midi' with 1200 – 2400 Wp nominal power). This electric design was made without differentiation of the module orientation, as the inclination is only 9º (always to the centre of the roof) and the three strings could be interconnected with short ways to the cable inlet. The inverters are placed in the entrance area, directly beside the three electricity meters. One of them is for feeding electricity back to the utility's grid, one is for buying electricity during daytime and one for electricity consumption in the night-time. It is foreseen to feed electricity directly in the BEAR Architecten office. Only the PV-electricity, which is not needed immediately, is fed back to the grid - for example on sunny weekends, when the office is closed.



Figure 5 Transparent PV modules

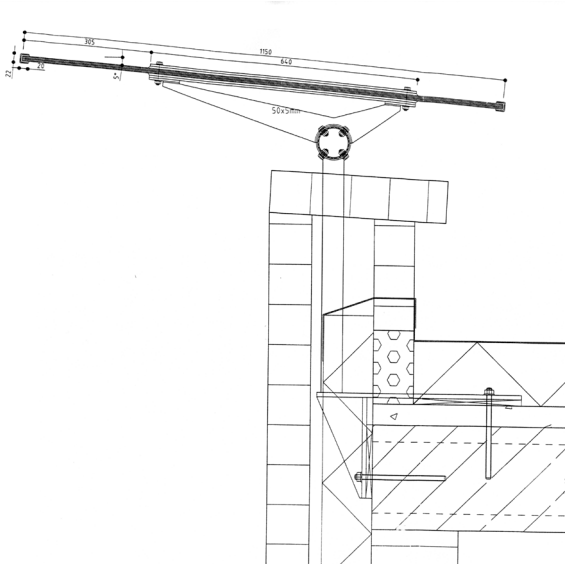

Figure 6 PV roof above the façade.

3.3 Monitoring

Measurements are permanently performed with the program 'EnergieMonitor', developed by Econergy. It is installed on a separate computer for monitoring, placed directly beside the inverters. The PV-system is in operation since mid November 2000. Data will be available in a later stage.

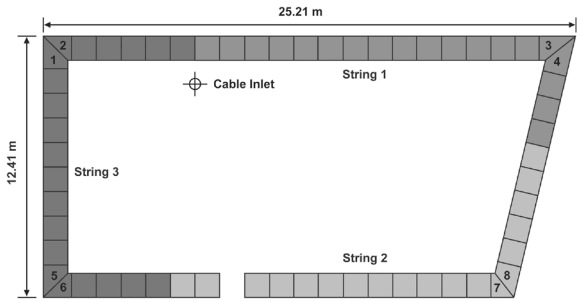

Figure 7 Overview of the strings

4. SCIENTIFIC INNOVATION AND RELEVANCE

The idea of canopy PV-roofs placed on attic walls of flat building-roofs has a high potential. Modern architecture with its flat roof design let to façades that are not protected against rainwater. Water running down the façade, causing stripes and damaging walls, will colour and pollute the façade. A canopy construction is a good solution to solve this problem. Furthermore the canopy leads to less weight on the roof as no additional weight is needed compared to independent support structures (the classical flat roof PV-systems). The PV-canopy is as well a functional as an aesthetic solution.

5. RESULTS / CONCLUSIONS

It turned out, that it is a very good possibility to use PV-modules as protection above walls. Especially as the roofs are small and the attic walls will shade part of the roof. The PV-modules function as protection for the attic walls and substitute a horizontal metal covering, the PV-modules protect the façade against rainwater. Furthermore this solution can also function as sunscreen as the canopies are bigger.

The more or less horizontal installation (9°) allows optimal use of space especially in an inner city neighbourhood with small roof areas and a lot of shade on facades. Besides the system is independent of orientation and seems very suitable for existing buildings.

6. PARTNERS

Design: BEAR Architecten, Gouda, the Netherlands.
Canopy study: Octatube, Delft, the Netherlands.
PV system: BST, Terheyden, the Netherlands.
Canopy construction: Nees de Jong, Stolwijk, the Netherlands.

A Proposal for using a system of principles and indicators of housing quality and sustainability in Hungary

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1. INTRODUCTION

In Hungary, and so in other countries in the region, many housing experts point out, that housing problem is related here mostly to problems of quality. Though for decades posters and slogans proclaimed that the main value was the human being, exactly when housing, the living place of people was addressed, the real needs of people were neglected. During the period of socialism, getting a flat was seen as a basic human right with the concomitant of mass housing. The dominating technocracy, the pure quantitative – and not qualitative – requirements resulted in a relatively large number of new housing units, however mostly without considering the real human needs of the users.

The problem of housing quality still exists, though in another dimension. This includes either the low quality of execution in case of family investments in own family houses constructed with very limited budget or the low architectural (and in several cases also functional) quality of luxury family houses built by the new rich. Thus, a significant part of new constructed houses cannot meet up-to-date quality requirements, not to speak about the issues of sustainability. Currently, only the building regulations prescribe some quality requirements, however these regulations hardly deal with more complex requirements of a living environment, with environmental and health aspects, with the issue of architectural quality and harmony of the built environment. Current housing policy also addresses mainly quantitative aims (as 40000 new housing units/year) and this consequently has a risk of inadequate quality.

With an intention of providing a tool for improving quality, this paper introduces a proposed system of quality requirements and indicators in housing. This tool can serve as a basis for design and investment, for future financing and housing subsidy system in order to finance and subsidize good quality housing and for research & development programs in this field. The awareness of and dealing with the complex problem of quality can help to construct houses, which pay respect to environmental and human aspects, and by taking into account the personal needs of future users, can become really homes.

ACKNOWLEDGEMENT

I am indebted to Dr. Károly Matolcsy, Dr. Bálint Petró and Dr. Tamás Bánky, who had assisted the work, on the bases of which this paper was written.

2. THE INCREASING SIGNIFICANCE OF QUALITY

Concurrently with changing lifestyles and the increasing peace of life also housing needs and requirements are changing. New demands have emerged such as flexibility, adaptability, accessibility, increased comfort, health and security, energy-efficiency and sustainability. The performance in these issues became a major concern of quality.

Considering the long lifecycle of buildings, we have to take the consequences of every decision we make or we do not make for a century at least. While the built environment represents the largest part of the national asset, improving the quality of it is a main challenge of national economical strategies. Also for the government and for financing institutions, it is very important to know for what (which quality) they give support or credit. Living conditions have wide socio-economic and cultural effects and are a major factor in the general quality of life. Thus, improving housing quality is a stressed public interest.

3. THE NEED FOR SUBSIDIZING QUALITY

For guaranteeing quality and the stability of value of new housing, proper financial tools and subsidies are needed. Between the cost of adequate quality and the disposable financial tools often raises a gap, the filling of which is hardly possible without housing subsidies. Without government subsidies, the measure will remain the wallet, which generally has a finite content.

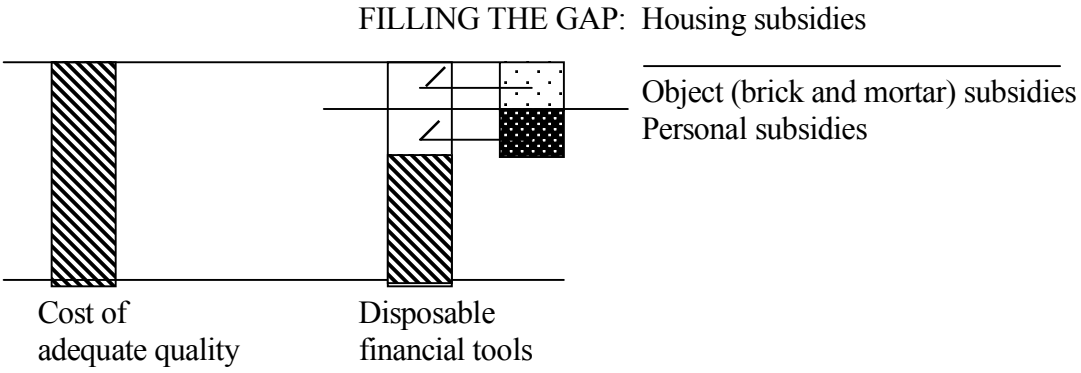

Figure 1 Filling the gap between the cost of adequate quality and disposable financial tools by housing subsidies.

Obviously, for increasing the sustainability in housing and for improving the quality of life, good quality flats should be constructed in the highest possible proportion. In order to guarantee this, one could suggest that:

- housing subsidies should be made dependent upon strict conditions of quality,
- better quality should get more subsidies.

Thus, on the one hand: the general practice of housing subsidies should be based on certain quality requirements. Without fixing up-to-date requirements of basic quality, no housing strategy can be effective. In addition to this, premium requirements of quality could be described that make possible to give higher preference to higher quality (e.g. higher performance in sustainability, ecological and health requirements). In this way, the slogan of "quality and choice" can refer also to choosing quality. On the other hand: special support should be given for those innovative research & development programs and reference projects, which could demonstrate the principles of sustainable housing in larger scale and with model value in these countries.



Figure 2 New condominiums and "residential parks" in Buda with high level of quality requirements
a.) Condominium in Pasarét. Architect: Vánzca architects
Source: Tojás 2000. October-November
b.) "Residential Park". Architects: Ferenc Cságoly & Ferenc Keller
Source: Alaprajz 2001/4
c.) Condominium in Rózsadomb. Architect: Lajos Kuknyó
Source: Tojás 2000 December – 2001 January
d.) Condominium in Óbuda. Architect: Árpád Marillai
Source: Alaprajz 2001/4
e.) "Residential Park". Architect: Sándor Dúzs
Source: Alaprajz 2001/7

4. A PROPOSED SYSTEM OF QUALITY REQUIREMENTS

In ÉMI Npc a complex system of quality requirements of sustainable housing was proposed and worked out by the author of this paper. This contains 350 requirements or guiding principles divided in 5 main thematic groups and several chapters within each group. The thematic groups and the chapters are as follows:

I. Location, urban life and environment
- Quality of the built environment
- Green areas and natural environment
- Social environment and cultural heritage
- Economical environment, labour market
- Environmental loads and pollution
- Soil and its protection
- Amenities, services, education and leisure

- Accessibility, infrastructure and public utilities

II. Developing the building site
- Site layout
- Landscaping and garden
- Public, semi-public and play areas
- Private and shared open spaces
- Security of site and buildings
- Routes and movement on site
- Car parking

III. Architecture and residential function
- Fitting in context, consistency and harmony
- Forms and proportions
- Orientation, insolation and views
- Size of unit and rooms, number of rooms
- Flat layout: function and flexibility in use
- Layout of rooms: potential in use and furnishing
- Access, movement and storing within the flat
- Privacy and separation, zoned planning
- Safety in use
- Accessibility and adaptability

IV. Sustainability of building structures and technology
- Mechanical resistance and structural stability
- Lifetime and durability
- Safety in case of fire
- Protection against noise and vibration
- Economical issues, cost-effectiveness
- Embodied energy
- Energy balance and heat control of the building envelope
- Indoor air quality, avoiding harmful emissions
- Humidity and moisture control
- Ventilation
- Useful and harmful radiation, control of electrosmog
- Further aspects of health, building-biology and ecology
- Convertibility for future needs
- Demolition, construction waste management and reuse

V. Sustainable use and operation of buildings
- Energy balance, use of renewable energies
- Water management
- Management of household waste
- Maintenance and changing elements
- Post Occupancy Evaluation and user satisfaction

5. INDICATORTS OF HOUSING QUALITY

In order to adapt the principles of quality and sustainability to practice, especially regarding the practice of housing subsidies, the next step should be to measure the level of performance in satisfying the addressed requirements.

Several good examples exist for sets or systems of indicators measuring housing quality and sustainability. A Housing Quality Indicators (HQI) system was designed by the Department of the Environment, Transport and the Regions in the UK in order to allow potential and existing building schemes to be evaluated on the bases of quality. Systems of indicators are used in several countries in order to measure the quality and the sustainability of housing or other building and urban projects (e.g.: EcoProp eco-efficiency indicators, Green Building Challenge indicators, REKOS and PIMWAG eco-efficiency indicators for residential buildings in Finland, Hammarby Sjöstad urban project indicators in Sweden, Total Quality Building Assessment System in Austria, etc.). The thematic network of CRISP running under the 5th RTD Framework programme of the EU is dealing with construction and city related sustainability indicators. As a member of this network - and connected to the work of CRISP - ÉMI Npc has also started to work out a national system of indicators for sustainable construction in Hungary. A wide professional working group assists this work. One of the 10 main indicator groups is dealing with housing and housing quality.

Indicators were started to be worked out also in connection to the 350 requirements, the main topics of which were discussed above. Through the indicator examples several priorities in recent housing and urban planning are emphasised such as:

- planned urban development and socially balanced housing environment,
- environmentally flexible infrastructure,
- proper scale,
- ecological and health requirements,
- energy saving, etc.

6. EXAMPLE OF INDICATOR AND PRACTICAL USE

As an example, the chapter of “size of unit and rooms, number of rooms” emphasised the aim of proper scale through requirements such as:

- Number of rooms should correspond to household composition (a separate table shows the preferably needed number of rooms for different households)
- By classifying the net floor area of flats in a housing project according to the number of users, floor areas should range between a proposed minimum and an appreciated maximum (as regards subsidies) as an attached table shows it. A better approach towards the middle values is preferred, etc.

For measuring the performance in case of the 2nd requirement, Table 1 demonstrates a potential indicator and its evaluation. In the table the columns represent the number of household members while the rows represent the categories. Each category shows a range of floor areas. Category 1 represents those flats, which have smaller floor area than the proposed minimum. Category 5 represents those flats, which have larger floor area than the appreciated maximum in subsidies. Category 3 represents the “optimal” range. The categories 2 and 4 are transitional. In the evaluation process the proportion of units falling within each categories should be documented.

Table 1 Classifying in categories (1-5) the net floor area (m^2) of flats in a housing project according to the number of users.

N° of users / Category	1	2	1	4	5	6	7	8	% of units
1	<30	<45	<55	<65	<75	<85	<95	<105	( )
2	30-35	45-48	55-60	65-71	75-82	85-92	95-102	105-112	( )
3	**35-40**	**49-51**	**60-65**	**72-78**	**83-91**	**93-101**	**103-111**	**113-121**	( )
4	40-45	52-55	65-70	79-85	92-100	102-110	112-120	122-130	( )
5	45<	55<	70<	85<	100<	110<	120<	130<	( )

Evaluation: The proportion of flats meeting the requirement of each category should be multiplied by determined values, for example by the followings: 0 for category 1 and 5; 50 for category 2 and 4 and 100 for category 3. The result will be a percentage showing the performance of this indicator.
For example: category 1: 0% of the flats; category 2: 20% of the flats; category 3: 45% of flats; category 4: 30% of flats; category 5: 5% of flats. The result will be: 0 + 0,2 x 50 + 0,45 x 100 + 0,3 x 50 + 5 x 0 = 70%

By using this indicator, proper scale can be a condition of getting certain (brick and mortar) subsidies in a new housing project. One can also suggest limiting certain personal subsidies or housing allowances for an appreciated maximum floor area according to the number of users (e.g. 45 m^2 for 1 person, 55 m^2 for 2, 70 m^2 for 3, 85 m^2 for 4 persons, etc.) It could be also prescribed, that above this subsidized part, a certain percentage of floor area is permitted, however this part will not get subsidies (thus, only a proportional part of the full potential subsidy will be available). In case of even larger flats no subsidy would be available. As another example, if the criteria of affordable housing is recorded (one of which can be the proper scale), higher subsidy level could be proposed for a new project containing affordable housing units above a fixed proportion. This tool -when applied in the practice of subsidies - can assist the aim of providing proper scale and also the aim of creating socially balanced housing environments.

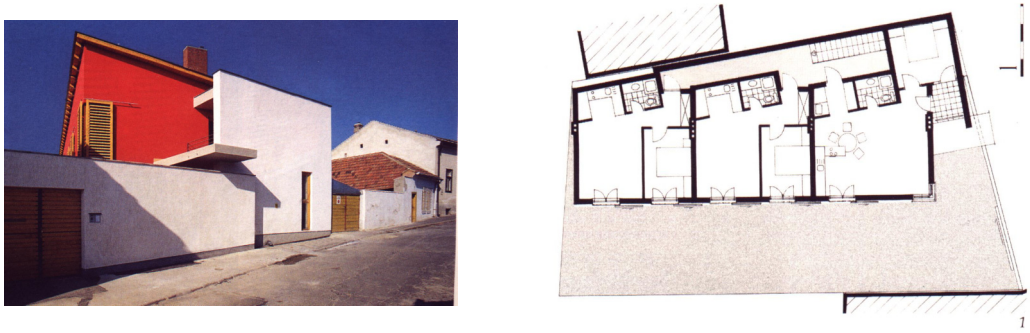

Figure 3 Studio flats for young families or university students, Pecs. Architect: Margit Pelényi. The flats were designed with proper scale for the users' needs and the building fits with proper scale and style to the Mediterranean character of the provincial urban fabric of the city. Source: Alaprajz 2001/6

7. CONCLUSION

A complex system of principles or requirements and adequate indicators of housing quality and sustainability can be a useful tool for architects and planners, for investors and developers, for financial institutions, for governmental bodies and local authorities. By using this system, quality aspects could be integrated in housing policy and in the system of housing subsidies. This can assist EU applicant countries to fulfil the EU standards in the field.

Prediction of energy efficient measures in new multi-family buildings

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1. INTRODUCTION

In about 40–50 years, it is estimated that there will be twice as many people on the Earth. The majority are expected to settle down in cities. The quick urbanisation requires us to create sustainable development for our cities. In Western Harbour, in the city of Malmö, a new area has just been built. The intention is to form a sustainable area that is supplied by energy from only renewable sources. To get a sustainable balance between supply and use of energy, there is a demand on the buildings to be energy efficient.

The area was erected as part of a building exhibition, Bo01, which took place in the summer of 2001. In connection with the exhibition, a quality program was written to secure the implementation of the ambitions for the area (Dalman, 1999). It defines the quality level that is needed from the developers who are involved in the construction process. The quality program deals with many areas, such as waste management, biological diversity, energy, transport, and architecture.

The Swedish government has allocated about 250 million SEK in grants to Malmö City for the Local Investment Program for environmental measures at Bo01 (SFS 1998:23). Principally, the grants have gone to the developers to cover the excess costs of meeting the environmental goals in the quality plan and to Malmö City for investments in technical systems and infrastructure. Some money was allocated to research projects that will evaluate the different environmental measures.

My research project deals with evaluating the energy use in multi-family houses in Western Harbour. This paper is about the developers' expectations of different measures in order to decrease energy use. According to the quality plan, the average of the annual energy use is not allowed to exceed 105 kWh/m^2 (Dalman, 1999). That is the total energy use that includes energy for heating, warm water, common, and real estate electricity. The aim is to see which measures the developers use to produce energy efficient buildings and if their estimated energy savings agree with known knowledge.

While energy use is strongly connected to emissions of carbon dioxide, it is of great importance to confirm which measures in buildings lead to energy efficiency and preserve good indoor climate. To follow the Kyoto protocol and the Swedish environmental quality objectives (Gov. Bill 2000/01:130) the building sector has to be more prepared on resource efficient construction than it is today.

2. METHOD

Only multi-family houses are of interest in this study. Every developer has had the opportunity to apply for grants from the Local Investments Program (LIP) and most of them have applied. From the applications, I have assembled the different measures the developers have completed in order to lower the energy use. By comparing the developers' expected

savings from the different measures with literature, one can get in indication of how realistic the assumptions are.

It was requested by the Bo01 secretariat to hand in energy calculations for all building projects. Most of the calculations have been done in the program *Enorm*, which are the ones I have examined. It will be questioned if Enorm is proper tool to predict energy use. I also have studied their input data to see if it is reasonable figures to predict the actual energy use.

In addition, I have also had the opportunity to study the contents of interviews with the architects (Dalman, 2000) and the developers (Öst, 2002), to get a background, and another point of view, on energy.

3. RESULTS

As a background it is interesting to know the developers' and architects' thoughts about energy efficiency. According to interviews with the developers, they do not think it will be difficult to meet the demand of 105 kWh/m^2. When studying the interviews with the architects, only two showed both knowledge and interest in making houses energy efficient. One architect prefers double-pane windows and not too much insulation because he believes there is a risk for moisture in the walls.

3.1 The LIP-applications

Nine or ten measures are dominant in the applications. I intend to concentrate the evaluation around these (Nilsson, 2001). All ten measures are known techniques, methods or products, not necessary always implemented in houses for one reason or another. The trend that can be gathered from the LIP-applications show that it is a *combination* of those measures that is new. Not much literature exists regarding the evaluation of a combination of measures. That is why Western Harbour is an area with the potential for valuable experience about energy efficient construction. None of the houses can be seen as experimental buildings, since they all are erected with the intention to become marketable. Although the investments have been a bit higher, the LIP-grants seem to have worked as an attraction.

The effects of the ten measures will be shown separately and the developers' estimated savings will be compared with what has been found in literature about each measures' potential of being energy conserving. The applications are varied in detail and in many cases no initial value has been stated, which makes the evaluation somewhat difficult. See Table 1.

Low energy windows

Windows stand for a considerable part of the transmission losses in a building. The heat flow through a window is about ten times larger than through an external wall. Lately the development of windows with lower U-values has progressed. Two panes of glass sealed in a frame with, for example, argon or krypton between the panes lower the heat transfer. By providing one pane with a low emission coat, the heat radiation from the room through the window will be blocked. With that type of construction in a well-insulated frame, you get low energy windows with a U-value of about 1,0–1,3 W/(m^2·K) (Bülow-Hübe, 2001).

The developers have estimated to save about 5–12 kWh/m^2 by choosing low energy windows instead of triple-pane windows. One can estimate the savings by calculating the difference in heat transfer between common and low energy windows, showed that the developers have utilised reasonable values.

Additional insulation
Thicker insulation, accurate construction technique and proper workmanship will likely result in less transmission losses. A well-insulated construction is also more sensitive to defects, for instance a gap in the insulation. Research indicates that convection in insulation can lower the insulation effect considerably (Elmroth et. al, 1991 and Roots, 1993). In the *Stockholm project* (Elmroth et. al, 1989) no disadvantages were found due to high-grade insulation and the expected effect of the insulation was achieved.

The developers' estimated savings have a great span because some developers allow the effect of low energy windows. Some have specified their normal U-values for wall and attic as U= 0,25 W/(m^2·K) and U=0,20 W/(m^2·K) for foundation. Improved values with more insulation for wall and attic are U=0,15–0,20 W/(m^2·K) and U=0,10–0,18 W/(m^2·K) for foundation. Calculations have shown that the developers have made reasonable estimations of the savings.

Table 1 This table shows the ten most common measures according to the LIP-applications. The developers estimate the savings according to the figures in the table. The chosen value is what the developers have specified to use in their project. The common value is rarely mentioned in the applications and refers to what they usually choose in common building project. E.g.: a developer chooses low energy windows with U=1,2 W/(m^2·K), compared to more common windows with U=1,8 W/(m^2·K). The developer estimates the savings to be about 8 kWh/m^2.

Measures	**Savings**	**Chosen value**	**Common value**
Low energy windows	5–12 kWh/m^2	U=1,0–1,3 W/(m^2·K)	U=1,7–2,0 W/(m^2·K)
Additional insulation	0,6–21 kWh/m^2	50-100 mm extra insulation	circa 170 mm
Heavy building	0,3–4 kWh/m^2		missing
Reduce effects of thermal bridges	1,8 and 5 kWh/m^2		missing
White goods	0,06–5 kWh/m^2	EU-class A	EU-class C
Low energy lamps	1,4–4,6 kWh/m^2		missing
Energy efficient pumps and fans	3 and 29 kWh/m^2	< 0,5 kW/(m^3·s)	missing
Demand controlled ventilation	5–24 kWh/m^2		missing
Individual measurement	4–26 kWh/m^2		missing
IT	0,9 kWh/m^2		missing

Heavy building
From Ståhl's (2000) thesis about the effect of the building's mass, a small difference between a light and heavy building is shown. The U-value has a much larger influence on the energy use than the building's mass. Although a heavy building can present other qualities, such as better airtightness, reduced effect of thermal bridges and a more balanced indoor climate.

The developers' estimations of 0,3–4 kWh/m^2 are reasonable according to literature, but any significant energy savings from a heavy building is not expected.

Reduce the effect of thermal bridges
Thermal bridges result in heat losses and less comfort in buildings. In an ordinary building, thermal bridges can cause as much as 20–30 % of the transmission losses according to

Anderlind (2000). Levin and Mao (1993) found it varies between 2 and 21 % when they examined the effect of thermal bridges in three multi-family houses. The variation depends on how the intersection of the wall and floor is constructed. Consequently there is a potential of heat saving through more precise design and erection.

Two developers have estimated their savings through more precise design. Although this measure is connected with additional insulation, some developers might include the effect of reduced thermal bridges. It ought to be natural to take thermal bridges into consideration during the design stage. No conclusions can be drawn whether or not that has been done. Only two developers have included thermal bridges in their energy calculations.

Energy efficient white goods
The Swedish Consumer Agency (2000) has done a market survey over energy efficient refrigerators and freezers. The refrigerators in EU-class A are about 36 % more efficient than in EU-class C. For freezers the same relation is about 44%. With a refrigerator and a freezer in EU-class A, one can save circa 300 kWh/year or 3 kWh/m^2 if the apartment is approximately 100 m^2.

The developers estimate that refrigerators from EU-class A are about 30 % more efficient than refrigerators from EU-class C. Savings between 1 and 5 kWh/m^2 seems reasonable.

Low energy lamps
Low energy lamps are more efficient than incandescent lamps because they convert 25 % of the electricity to light, compared to 5 % for incandescent lamps. The rest is emitted as heat to the room. Many factors influence how much can be saved by changing lamps, according to a publication from the Swedish Energy Agency (1998), but approximately 50 % of the electricity for lighting can be saved.

Since the developers have not stated any initial value for lighting, it is hard to know what to compare 1,4–4,6 kWh/m^2 with. While the savings are dependant on many factors, they might be overestimated.

Energy efficient fans and pumps
There are a lot of aspects to take into consideration when designing an energy efficient ventilation system. Fan and pump motors ought not to be overdimensioned. The motor power will not be utilised when motors are too large, which will cause low efficiency. Too much resistance in aggregates, filters and canals will result in large fall of pressure that leads to high electricity use (Nilson et. al, 1997 and Isaksson et. al, 1994). That makes it difficult to estimate savings from energy efficient fans and pumps, but to save as much as 29 kWh/m^2, as one developer has stated, seems too optimistic.

Demand controlled ventilation
There are many ventilation systems that do not work satisfactory, hence the search for better solutions. Engdahl (1998) has evaluated 5625 ventilation systems in Sweden and found only 34 % of them to pass the obligatory ventilation control. Ventilation systems should be robust, easy to operate and preferably be adjustable to the residents' demands. Demand controlled ventilation can be a solution, but experience is required because most systems are found in commercial buildings and not in dwellings. Therefore, it is difficult to say whether the developers have reasonable estimations of energy savings. The large span in values in Table 1 may indicate too little knowledge about demand controlled ventilation.

Individual measuring of heat and warm water
Research show that the potential of heating energy by informing the residents about their energy use is highest for older buildings that are not well-insulated (Berndtsson, 1999). With a properly adjusted heating system the savings might be lower than 10 % of the heating energy. Greater potential exists for warm water, where savings are estimated to 15–30 % of the energy that normally heats up the warm water. The developers' stated savings might be a bit high, while the savings depend on the residents' willingness to be energy conscious. In stated figures, savings from electricity might also be included (see the next paragraph about IT).

IT
When IT is mentioned as a saving measure, the developers aim at a tool to monitor and regulate one's energy use. Research shows a connection between energy statistics and how it affects the consumers (Matsson, 2001). More information to the residents can result in about 2–12 % savings of electricity use. The savings here also depend on the residents' behaviour, while the developers' estimated savings are problematical to control.

3.2 Energy calculations
All energy calculations that have been handed in, indicate an energy use lower than the demand of 105 kWh/m^2 in the quality program. Although it can be questioned whether the calculation program they have used will show the actual energy use.

Windows – the calculation program is designed for houses with window areas of 15–20 % of the useable floor area. Average window area for the projects in Western Harbour is about 29 %. This causes more sun energy into the buildings than the program can take into consideration because it has a one-day resolution versus a one-hour resolution.

Thermal bridges – the majority of the developers do not compute the effects of thermal bridges. According to the Swedish building code, it is not required. But if the actual energy use shall be predicted, thermal bridges must be included.

Indoor temperature – the developers calculate using 20 ºC while the actual indoor temperature for multi-family houses is 22 ºC. Those two degrees increase the heat demand by about 10 %.

Airtightness – most developers calculate using 0,8 l/(m^2·s), which is the level for dwellings according to Swedish building code. Only manual measurements can answer if the houses are airtight or not. Western Harbour is exposed to strong winds, which can increase the airleakage when large pressure differences occur between outdoor and indoor.

Average U-value – the building envelope has to have a certain amount of insulation according to the Swedish building code. It is allowed to decrease average U-value for the building by 30 %. The majority of the developers have an average U-value that lies between the demand and the limit of what is permissible. If the heat demand increases according to the arguments above, the developers should have improved the design of their buildings to have better potential to meet the demands in the quality program.

4. CONCLUSIONS

The energy calculations will probably fail to estimate the actual energy use correctly. The calculation program used was originally developed to ensure that a building follows the Swedish building code. It is not a very precise tool for significant forecasts. Measures to decrease the energy use seem to have a low priority among developers. There is little demand for energy efficient buildings from the real estate sector and little pressure from the government.

On a closer examination of the energy calculations and the LIP-applications, it is physically uncomplicated to estimate the effect of energy efficient windows and additional insulation. But it is more difficult to estimate measures that are affected by human behaviour and level of workmanship. At this point the developers are a bit optimistic and do not take safety margins into account.

When the developers do their estimations of future energy use, they do not see the building as a whole system. They usually add savings from each measure when it normally is not physically feasible. Reasons can be no incentives for the developers to be energy efficient and little knowledge about combinations of different measures. That is probably because evaluations of building projects are rare and feedback to the building sector is lacking.

The quality program has put energy in focus and this evaluation will provide useful feedback that will benefit the building sector. We will know about a year whether or not the buildings in Western Harbour are energy efficient. The energy use will be measured every hour to get decent statistics about the actual energy use.

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lioEcological Footprints and Sustainable Urban Development

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INTRODUCTION

My home is my castle. But my home is also my cathedral; *a cathedral of consumption*. This is a concept launched by the American sociologist George Ritzer (1999), and is connected to his theory on *the new means of consumption*. Such means are settings that not only allow people to consume a wide range of goods and services, but are structured to lead and even coerce people into consumption. Among them are the *cathedrals of consumption*; they have an enchanted, even religious character for many people, and have been become locales to which people make "pilgrimages" in order to practice the consumer religion. Shopping malls and amusement parks are obvious examples. But similar processes are going on in other arenas as well; athletic and football stadiums, theme parks, museums, and also universities (Ritzer 1999). A most usual course chosen is the "spectacle" of *enormous physical space*; ever larger malls, amusement parks and the like. The results are larger buildings and parking lots, and more extensive encroachments into natural and other valuable land areas (Høyer and Næss 2001). Our focus is on the house; the family dwellings of the late modern consumer society. The conception of cathedral of consumption is somewhat different from George Ritzer. The house is *not* a locale where a lot of people make "pilgrimages". It is a locale which attracts large and continuous streams of material resources; it is an attractor for extensive metabolism with its environments. The private car belongs to the house. It extends the physical outreach and makes all the "pilgrim" travels carried out by the household members possible. The car and its infrastructure – roads and parking lots – are closely interconnected with the late modern consumer society. In itself the car, and everything that belongs to it, is a major focus for consumption. But its use is also a constitutive factor for other forms of consumption, in the daily conditions of production and reproduction and in leisure time as well (Høyer and Næss 2001).

THE ANALYTICAL MODEL

Our research project is based on the understanding that physical structures are important in forming human attitudes and actions. The central unit is the household and the house which it inhabits. Various characteristics of the household and the house will give rise to the household's overall consumption pattern and consumption volume. This consumption is in turn the source of various forms of environmental demands (energy consumption, material resources consumption etc.). Characteristics of the household and the home in which they live constitute independent variables in the project. The quantities which are to be explained, consumption and demands on the environment, are the dependent variables.

Through housing planning and development the foundations are laid for the physical/structural conditions attached to the house and its location. This process in itself gives rise to environmental demands in the form of energy and material resources consumption in connection with the construction of houses and necessary infrastructure. The physical/structural conditions contribute moreover to the creation of a *requirement* associated with the various forms of housing-related activities (heating, daily transport, maintenance etc.). This requirement affects the household's *behaviour* and consumption, which in turn lead to different environmental demands (Høyer and Holden 2001).
The physical/structural conditions are however not solely determining consumption pattern and volume. Attitudes and lifestyle influence both requirements and behaviour. However there is a reciprocal connection between attitudes/lifestyle and requirements. By this we mean firstly that the requirement affects the household's lifestyle, but also that the attitudes/lifestyles we bring with us influence our choice of living conditions. An important characteristic in this connection is of course the socio-economic and socio-demographic background conditions. These directly influence requirements bearing on housing-related activities. They influence moreover the requirements indirectly by way of the choice of living conditions and lifestyle.

METHODS

The *research plan* for the project consists of an empirical part and a theoretical synthesising part. In the empirical part focus is on the relationships between housing-related consumption and factors that affect the extent and composition of the consumption. In the theoretical synthesis the results of the empirical research is incorporated in a theoretical perspective and discussed in light of other knowledge. This also involves a discussion of principles and criteria which may be used in planning and design of residential areas in the light of sustainable development objectives.
The *empirical* research plan consists of three phases, each with its own separate approach
They are: *Survey, Case-studies* and *Ecological footprint analysis*. All are carried out among a large number of households in the Norwegian towns Førde, Storhaug and Greater Oslo in the years between 1998 and 2000. Greater Oslo, which comprises the capital Oslo and the surrounding district with a population totalling about 1 million, represents consumption pattern and volume in an large city context. Storhaug is a local area within the city of Stavanger, and represents a densely populated urban area in a medium sized Norwegian city. Førde, with about 12.000 inhabitants, is a small town in a rural district.
Four consumer categories are used and referred to as housing-related consumption. Firstly there is *energy consumption* for heating and operating purposes in the houses. A substantial amount of *material housing consumption* is further required to run and maintain the houses, and this is designated as the second consumer category. It concerns furniture and other fittings, technical equipment and electrical accessories, equipment for maintaining and running indoor and outdoor areas, etc. Energy consumption relating to *everyday transport* constitutes our third consumption category, and finally, *energy used for longer holiday and leisure trips* has been included as a fourth category. In addition to the housing-related consumption in the household, data on the following conditions have been collected:
1. Properties of the individual house: information is collected on housing type, its size (m^2 floor area), construction type (wood, brick, concrete) and the size of the building site (m^2).
2. The physical and structural properties of the surroundings: data have been collected on *inter alia* services within walking distance (500 - 1000 m) of the house (shops, public offices, commercial services and so on), the distance from the nearest service of each type, as well as the density of buildings in the close vicinity and local community. 3. Socio-economic and

socio-demographic background data on the individuals living in the households. 4. Environmental attitudes: attitudes in general, environment-political issues.

ECOLOGICAL FOOTPRINT ANALYSIS

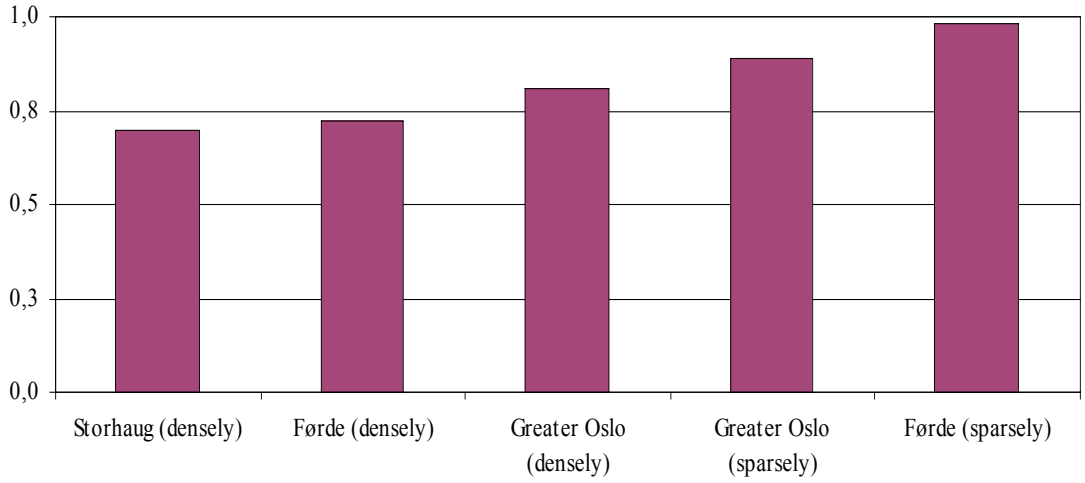
Ecological footprint analyses link consumption and environmentally sustainable development. They provide indications of the overall living situations that entail the least serious environmental consequences. In addition to the data obtained from the survey, the calculations are based on detailed empirical data concerning the environmental consequences of different types of consumption. The term "ecological footprint" was presented in the beginning of the 1990s by Canadian researchers who studied the amount of land needed by cities to support their populations. They defined an ecological footprint as "an accounting tool that enables us to estimate the resource consumption and waste assimilation requirements of a defined human population or economy in terms of a corresponding productive land area" (Wackernagel and Rees 1996:9). The basic idea is quite simple: We need land areas to produce food, clothes, timber, and fuels. We need land areas to build roads, houses, offices, parking space and railways. And, not to forget, we need land areas that make it possible for nature to absorb our emissions and waste. In other words, we need land areas to live. The ecological footprint for an individual is the sum of all these small and scattered land areas all over the world. The size of his or hers footprint depends on the consumption volume and the specific consumption pattern.

It is usual to operate with five different main land-use categories (Chambers, Simmons and Wackernagel 2000, Høyer 2002). The categories are: (i) land for biological diversity, (ii) biological productive land, (iii) biological productive sea, (iv) energy or CO_2 land, and (v) built-up land. The second category, biological productive land consists of three sub categories: (a) arable land, (b) pasture and (c) forests. The "energy land" component of the ecological footprint can be calculated in several ways. For converting *fossil energy* consumption into a corresponding land area, the preferred method is to estimate the land area needed to sequester the CO_2 emitted from burning fossil fuels. Estimating the ecological footprint of a defined population is a multi-stage process. The idea is that for every item of material or energy consumption, a certain amount of land in one or more land categories is required to provide the consumption-related resource flows and waste sinks. Thus, to determine the total land area required to support a particular pattern of consumption, the land-use implications of each significant consumption category must be estimated. It is useful to separate consumption into five main categories: (i) food, (ii) housing, (iii) transportation, (iv) consumer goods and (v) services (Wacernagel and Rees 1996, Chambers, Simmons and Wackernagel 2000).

THE SMALLEST ECOLOGICAL FOOTPRINTS

Figure 1 shows how the average household ecological footprint varies with residential area, distance from the centre of each of the three urban locations and housing type (Holden 2001). Note that the ecological footprints calculated only have to do with we term "housing-related" consumption and not to the household's total private consumption.

Figure 1.1; Residence area: densely vs. sparsely populated
Figure 1.2; Distance separated into three categories: 'near', 'moderate' and 'far'.
Figure 1.3; Housing types: Single family houses (SFH), semi-detached houses (SDH) and multifamily houses (MFH).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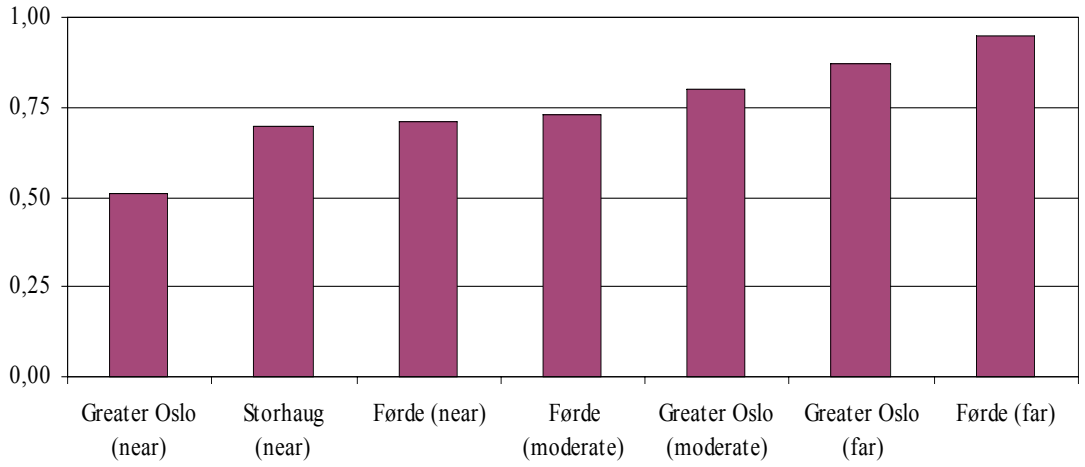
Greater Oslo (sparsely)
Førde (sparsely)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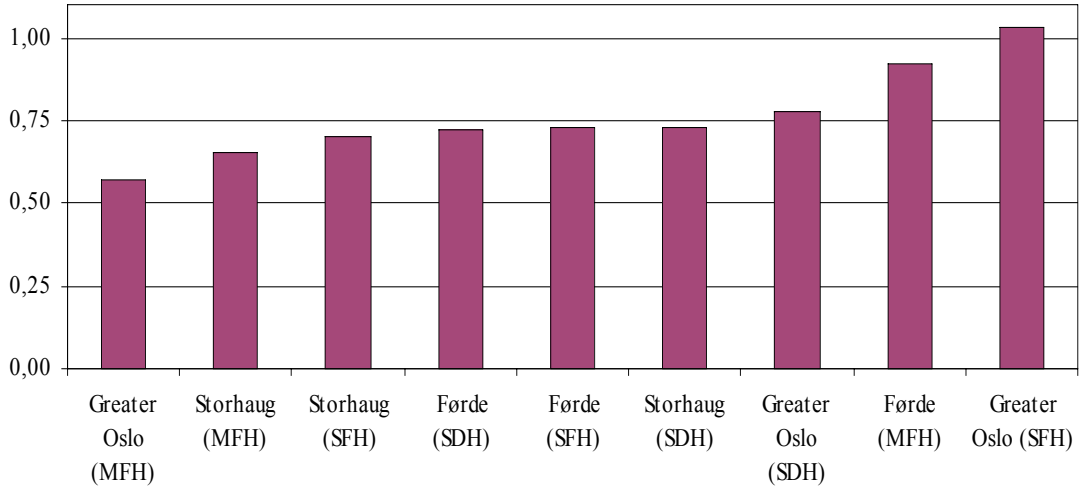
Storhaug (near)
Førde (near)
Førde (moderate)
Greater Oslo (moderate)
Greater Oslo (far)
Førde (far)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Greater Oslo (MFH)
Storhaug (MFH)
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Førde (SDH)
Førde (SFH)
Storhaug (SDH)
Greater Oslo (SDH)
Førde (MFH)
Greater Oslo (SFH)

Figure 1
Average ecological footprint per household member in Førde, Storhaug and Greater Oslo according to residence area (1.1), distance to the city centre (1.2) and housing type (1.3). All figures in hectares/individual/year.

SUSTAINABLE URBAN NEIGHBOURHOODS

The research presented in this article shows that the extent of environmentally harmful household consumption varies substantially with physical/structural conditions in housing areas. Empirical results regarding urban size, density and distance to the city centre can be related to the concept of *compact city* (Høyer and Holden 2001). This is a concept which has been highly focused in the 1990's discourse on sustainable urban development, and the amount of international research literature has become quite impressive (Jenks *et al* 1996, Newman and Kenworthy 1999, Næss 2000). Our research supports the assumptions that compact urban structures would lead to reductions in the ecological footprints of households and their houses. Firstly because shorter internal distances between the houses and public and private service give less mobility. Secondly because dense and concentrated types of housing give less energy use for heating and other technical equipment. But other forms of environmentally harmful consumption – the material housing consumption – are also less in the compact urban structures.

However, there remains an important aspect regarding urban size. In the compact city discourse two different pair of concepts are often mixed together without further qualification. They are *centralisation-decentralisation* and *concentration-sprawl*. The first refers to the population patterns in larger national contexts. The second to the development processes within urban areas. Since the early 1960's and the advent of the car-age, the development may be characterised as *centralised sprawl*. It has been centralisation of the overall national population pattern and sprawl of each and one of the urban concentrations. In some cases it has been concluded that the concept of compact city implies further centralisation of the population pattern and that larger cities are favourable in a sustainable urban development (Newman and Kenworthy 1989, CEC 1990). There is no support for such claims in our research. On the contrary, it seems to give more favourable ecological footprints to have a number of smaller compact towns and cities, rather than a few large or mega cities. This is termed *decentralised concentration*, and is in every aspect contrary to the dominating development patterns of the last decades.

But the large cities are there already. This raises the question of which development principles that are most favourable within the larger city areas. Is it the monolithic compact city? Our research also supported by later international research findings (Newman and Kenworthy 1999), on the contrary points to the necessity of decentralised concentration even within the larger city areas. It is a matter of creating *small towns within large towns*. This is strongly emphasised by Newman and Kenworthy (1999) as a crucial condition for a sustainable urban development. The term they adhere to such small towns is *sustainable urban neighbourhood*. It is among other characterised by; 1. High-density land use so that everything within the neighbourhood is within walking and cycling distance. 2. Mixed land use, with offices, shops, businesses, and community facilities integrated into residential development. 3. High density residential areas with multi family houses. 4. Pedestrian and cycle links with limited parking facilities. The aim should be a traffic-free, people oriented environment, not one designed around the space demands of surface parking lots. 5. A heavy rail or light rail station, or a major bus station, at the core. 6. Community facilites, such as schools, libraries, child care centres, recreation centres, and in some cases small urban farms. If these facilities are not within the neighbourhood, they are always nearby. 7. A high degree of self-sufficiency in the community to meet local needs, but with good rail and bus links to the wider city for

employment, higher education, etc. 8. Public spaces with strong design features (water, street furniture, sculptures, playgrounds).

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Choice of heat and electricity mix for environmental assessment of the built environment

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1. INTRODUCTION

Life cycle oriented methods are increasingly used for assessing potential environmental impacts of products and product systems. This counts also for the built environment (Forsberg & Burström, 2001). However, many assumptions are made in such assessments, potentially affecting the results and making the assessment more uncertain. To increase the reliability of environmental assessments (EA:s), consequences of the assumptions have to be better understood.

An important factor decisive for the overall environmental performance of a building is energy use in the operation and maintenance of the building (Bygga/Bo, 2000). According to Adalberth (2000), as much as 85 % of the total energy use during the life cycle of a building is related to the occupational phase, where it is used both for heating and electricity. In life cycle assessment (LCA), the selection of data for energy production is a general issue of debate (e.g. Ekvall, 1999). In all, this indicates that the choice of electricity and heat production data is an important methodological issue in (EA:s) of buildings and the built environment in general.

The purpose of this study is to investigate how assumptions and choices of data on heat and electricity production affect the assessed environmental impacts of buildings. Based on this analysis, and drawing from debates on the dealing with electricity data in LCA as well as the use of analytical tools in environmental decision-making, it also discusses how to choose heat and electricity mixes in EA:s of the built environment.

2. METHOD

To investigate the influence of modelling assumptions on the results of an EA, changes in environmental performance ranking of three buildings with different technical solutions for heat and electricity supply are analysed. The three buildings (Table 1), which are built in Hammarby Sjöstad, a new 'green' city district in southern Stockholm, are ranked according to their relative potential contribution to environmental impacts using environmental impact categories of LCA (ISO 14042:1998). The functional unit used is one square metre of usable floor area.

In the study, four different modes of electricity production (Table 2) and two different modes of heat production (Table 3) are used as independent variables. The first electricity mode applied is the Swedish marginal electricity production (E1), produced by coal condense power (Swedish National Energy Agency, 2001a). Marginal data represents the effects on the environmental impacts of a system if a small change in the output of flows from the system occurs. Representing a potential choice by an environmentally concerned electricity

consumer, Good Environmental Choice (GEC) electricity, as defined by the Swedish Society for Nature Conservation (2001), is the second electricity mode (E2) used in this study. More specific, wind power is chosen to represent the GEC electricity in this study. As opposed to marginal data there is average data, which in this study is represented both by Swedish electricity mix (E3) and Nordic electricity mix (E4). E3 stands for the yearly national average mix of Sweden including a small part of import, while E4 is the yearly average mix of the Nordic countries (excluding Iceland). E4 is of interest for this analysis due to the open trade market for electricity existing between these countries.

Table 1 Characteristics and heat and electricity demand for the three different buildings. (*Source*: Contractors in Hammarby Sjöstad)

Building characteristics	Building A	Building B	Building C
Number of flats	8	38	106
Usable floor area (m^2)	763	4 685	11 011
Heating system	Bedrock heat-pump	District heating	District heating
Solar panels (m^2)	250	-	500
Ventilation	Heat exchanger	-	Heat exchanger
Distributional survey	Electricity, heat, and tap water	Electricity, hot water, gas and tap water	Electricity, heat, and tap water
Up value of the climatic shell (W/K, m^2)	0.32	0.56	0.31
Frame material	Concrete	Concrete	Concrete
Heat demand (kWh/m^2, year)	0	62	44
Electricity demand (kWh/m^2, year)	82	27	26

Table 2 Power sources of the applied electricity mixes (%).

Electricity production	E1[1]	E2[2]	E3[3]	E4[4]
Hydro power			49.8	52.9
Wind power		100	0.2	0.7
Nuclear power			43.7	24.1
Heat and power plant, bio fuel			3.5	3.2
Heat and power plant, natural gas			1.0	0.4
Coal condense power	100		0.1	3.1
Heat and power plant, oil			2.2	17.1

1 Swedish National Energy Agency, 2001a. Coal condense power will according to SNEA be the marginal electricity production in Sweden for the following 5-10 years.
2 Swedish Society for Natural Conservation, 2001.
3 Swedish National Energy Agency, 2001b. Average between the years 1998, 1999, 2000.
4 Swedish National Energy Agency, 2001b. Average between the years 1997,1998.

Table 3 Energy sources in production of district heating (%).

District heating production	H1[1]	H2[2]
Heat pumps	46.4	
Oil boilers (fossil oil)	3.9	100
Oil boilers (pine pitch oil)	17.3	
Waste boilers	28.1	
Electricity boilers	3.3	
Bio fuel	1.0	

1 The Swedish District Heating Association, 2000. Average between the years 1998 and 1999.
2 Swedish National Energy Agency, 2001b.
As input data for district heating modes, the average district heating mix for southern Stockholm (H1) and oil based district heating (H2) has been used. H1 represents average production, while H2 represents marginal production.

In LCA the potential environmental impact is measured in impact categories. The impact categories analysed in this study comprise; global warming potential (GWP); acidification potential (AP); eutrophication potential (EP); and photochemical ozone creation potential (POCP). Another parameter measured is radioactive waste (RW). The impact data used for each production mode (Table 4) accounts for the impacts generated during the production and distribution of fuels and the electricity and heat production stages of the life cycle.

Table 4. Environmental impact from production of district heat and electricity per produced kWh.

Environmental impact category	H1[1,2]	H2[3]	E1[2]	E2[4]	E3[2,4]	E4[2,4]
GWP (g CO_2 eq.)	76	293	545	0.7	24	117
AP (mol H^+ eq.)	0.009	0.030	0.160	0	0.002	0.004
EP (g O_2 eq.)	0.95	2.71	1.43	0.23	0.37	0.55
POCP (g C_2H_2 eq.)	0.07	0.25	0.15	0	0.06	0.04
RW (g)	0.003	0	0	0	0.038	0.021

1 Birka Energi, 1998,1999 and 2000. Average data for district heat production southern grid Stockholm.
2 Uppenberg *et al*, 2001. Data for fuel production and distribution.
3 Hedvig Froste, Swedish Environmental Protection Agency, pers. comm., 1999. Modelled data from 1997.
4 Vattenfall, 1996.

The consequences of choosing different electricity productions and heat productions in an EA are analysed by combining the four electricity production modes (E1-E4) with one mode of heat production (H1 or H2) at each time while modelling.

3. INFLUENCE OF HEAT AND ELECTRICITY MIX ON THE ENVIRONMENTAL PERFORMANCE OF BUILDINGS

The implicit hypothesis in this study is that modelling assumptions, in terms of input data choices, have an impact on the results of an environmental assessment of products and product systems. If this hypothesis is true, it implies that the assumptions have to be carefully addressed and made transparent in environmental assessments.

Using the case of buildings, our analysis has shown that the choice of heat and electricity production mode in an EA has a large impact on the results of a comparative EA. As illustrated in Figures 1 and 2, showing the contributions to GWP, building A can either be ranked as the best or the worst of the three buildings, depending on what mix of electricity and heat production is assumed. When the buildings are compared using other environmental impact categories, the internal ranking was found to be the same as for the GWP case (Figure 1 and 2).

With data on the local average mix for district heating (Figure 1), building A is ranked the worst when using marginal (E1) and Nordic electricity production (E4) data, while it is ranked the best when using data GEC electricity (E2) or Swedish average electricity (E3) production data. With marginal data on heat production (Figure 2), building A has the worst grade when using marginal electricity data (E1) else the building rank is constant. Comparing building B and C, their internal ranking remains the same no matter what production data is used.

Comparing the overall ranking differences in Figure 1 and 2, the effect of using different data on district heating is revealed in diagram E4. In this case, building A is ranked as the worst when using local average data, but as the best when assuming marginal heat production.

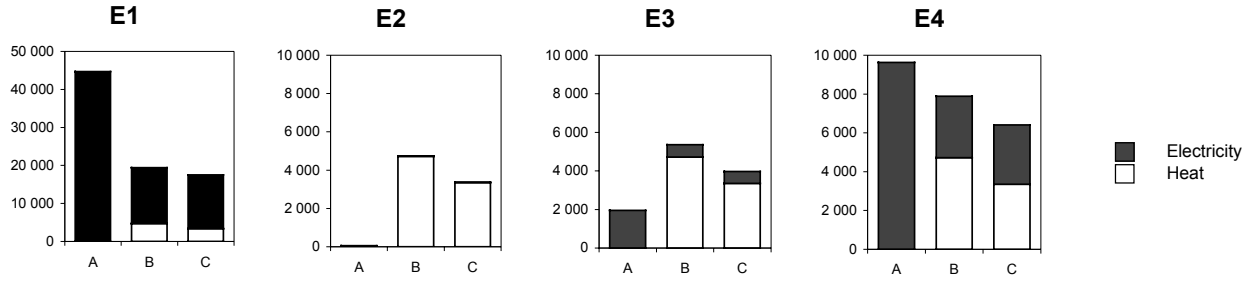

Figure 1 GWP (g CO_2 eq./year) for building A-C with different electricity production modes and constant heat production mode (district heating mix southern Stockholm). Observe different scales in each diagram.

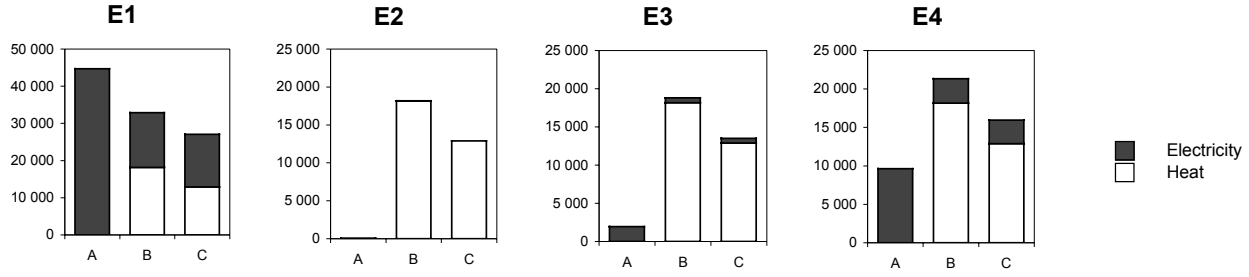

Figure 2 GWP (g CO_2 eq./year) for building A-C with different electricity production modes and constant heat production mode (oil based production of district heat). Observe different scales in each diagram.

4. HOW TO CHOOSE HEAT AND ELECTRICITY MIX?

From our analysis, it is clear that the assumption of production technology and thus choice of input data for heat and electricity production will be decisive for the results of an EA of buildings. Except for highlighting the need to address the modelling assumptions in EAs, this finding raises the question of how to actually choose input data in EAs. In the specific case of EAs of buildings and the built environment, what data on heat and electricity production should be used? Should we use average or marginal data?

As mentioned in the introduction, the question of using average or marginal data for (electricity) production technologies is a major methodological issue in LCA theory and practice. Reviewing what has been considered an appropriate choice of electricity (and heat) production mode in different LCA applications, as well as experiences from attempts to present standards or general recommendations on methodological issues in LCA (e.g. Consoli *et al.*, 1993; Dones *et al*., 1998; Kåberger & Karlsson, 1998; Ekvall, 1999; Ekvall *et al*., 2001) it becomes obvious that choosing data on electricity (and heat) production and the associated environmental impacts in LCA is not an easy task. Even when taking account of the specific purpose of a particular LCA, there seems to be contradictory suggestions as for what would be the most appropriate choice. This certainly makes it hard to present general recommendations on how to choose data on heat and electricity production in EA of buildings and the built environment.

From an overall perspective, we agree that the most adequate choice of data must depend on the purpose of the EA (Consoli *et* al., 1993) and the normative point of departure of the audience that each specific EA is intended to inform (Ekvall *et al*., 2001). However, design and construction of buildings and the built environment in general are activities with several stakeholders, representing different interests and ideologies (Smith *et al.*, 1998). Thus, it would be hard to identify a clear normative point of departure of the potential audience(s) of an EA of the built environment. Given that any decision-making situation related to the design of the built environment will present different, rival ideologies to the environmental analyst, it would also be hard to recommend anything but the use of both marginal and average data in any EA. Considering the significant impact the assumption of electricity production technology was found to have on the environmental ranking of the different buildings in this study, this would definitely be the case when choosing data on electricity production in an EA. Since any EA, no matter of its purpose can be used to inform decision-making, it would be wise to use both average and marginal data on electricity production in any EA. The results related to each of the chosen data should then be clearly communicated so as for the audience of the EA (i.e. potential decision-makers) to make the final assessment and ranking of the alternatives themselves. If possible, each assumption and its associated results could also be related to an ideology or normative position in order to facilitate the formulation of conditional conclusions (cf. Söderbaum, 2000). This means that the sensitivity analysis with marginal data suggested by Dones *et al*. (1998) would not be necessary. This would also open up for more democratic decision-making, which would be an overarching value in any democratic society. As argued by (Stirling, 1999, p. 120f) “no matter how much information is available, and no matter how much consultation and consideration are involved, no purely analytical procedure can fulfil the role of a democratic political process”. By the same reasons, no analyst can have the preferential right of interpretation and thus the right to present problems and solutions in a democratic political process. The decision should be made by the decision-makers and not by the analysts (cf. Söderbaum, 2000).

As mentioned, this would count for the use of data on electricity production, which is the more controversial of the two variables analysed in this study. As for the choice of heat production data, we could of course follow the same line of argumentation, but there are some special features of buildings as well as district heating systems that make it relevant to use only average data from specific, local district heating system in EA:s of the built environment. This would be irrespective of the purpose of the EA. First of all, any building or district heating system have a specific geographical location, and if connected to a district heating system, the building will get its heat supply from that specific heat producing system and no

other supplier. Consequently, it would give misleading results to use data on the production in another district heating system. Moreover, a building that is connected to a district heating system could be regarded as a long-term stable significant heat consumer. The economic lifetime of a building is approximately 50 years. Following the same line of reasoning as Kåberger and Karlsson (1998), it can thus be argued that the establishment of a new building connected to a district heating system, and even more so an entire city district, would not affect the use of heat producing plants serving as marginal production capacity. There is only one producer to contract and the contract would be long-term. Although the choice of heat production mode was found to affect the results of the assessed environmental impacts in this study, it would hardly be relevant to use marginal data even for a sensitivity analysis.

5. CONCLUSION

The purpose of this paper was to investigate how assumptions and choices of data on heat and electricity production affect the result of environmental assessments of buildings. Based on the study of potential environmental impacts of three different buildings, using four different modes of electricity production and two different modes of district heat production, it is concluded that the assumptions made on heat and electricity production technologies, and thus the data chosen on environmental impacts related to energy supply in buildings and the built environment, do have a large impact on the results of the EA. Depending on what data was chosen, the internal rank of the three buildings compared in this study shifted radically. This implies that assumptions have to be carefully addressed and made transparent in EA.

To deal with the ambiguities introduced in an EA of buildings and the built environment by the assumptions on production technologies related to energy supply, it is recommended that both average and marginal, as well as local specific (if available), data on electricity production should be used. This counts for EA:s focusing on consequences of technology changes in a building or if different building designs are compared as well as EA:s made for bookkeeping purposes. As for data on district heat production, it is recommended that it should always represent the average production in the specific, local district heating system to which the building would be connected, no matter what is the purpose of the EA. Finally, it should be added that the influence of the assumptions on the results should be explicitly communicated in the EA report, so as to let the decision-makers rather than the analysts make the evaluation.

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Assessment and design of a renovation project using life cycle analysis and GB Tool

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1. CONTEXT AND OBJECTIVES OF THE STUDY

Tools have been developed to assess the environmental quality of buildings. But beyond such an assessment, a more important issue is to help the actors to improve the performance of a project during the design phase. In order to study the possible use of assessment tools in a professional practice, two methods have been applied to the design of a renovation project concerning a social housing apartment building. After a description of the project and a presentation of the tools, the application and the results are presented, leading to some comments about the relevance of the tools and recommendations to both developers and users.

2. PRESENTATION OF THE RENOVATION PROJECT

A large part of the building stock in Greater Paris area has been built in the 60's and early 70's before any thermal regulation exist. These buildings were not insulated and their facades include a high percentage of windows with single glazing. The visual comfort is excellent, but the heating load is around twice the standard value for new constructions. The corresponding environmental impacts are high, and also the potential for improvement by renovation. We propose here to study the renovation of such an apartment building.

The municipality of Montreuil, a city located east of Paris, has launched a green neighbourhood pilot project. The municipal social housing office has planned a renovation project concerning 500 apartments. In one of the buildings including 52 dwelling units, a more energy efficient renovation is performed within the European REGEN LINK demonstration project.



Figure 1 : A typical social housing apartment building in Greater Paris Area

The renovation project aims to improve the general image of the neighbourhood, and a supplementary environmental objective is to reduce the greenhouse gases emissions by 25% compared to a standard renovation. The building is heated by a district heating system which uses fuel oil and coal as energy sources.

3. USE OF THE LIFE CYCLE SIMULATION TOOL EQUER

The ISO 14040 standard (1997) provides a definition of the life cycle assessment (LCA) method. This method consists in quantifying the substances taken from and emitted into the environment (e.g. raw materials, pollutants, waste…). In a further step, indicators are derived by adding the contributions of these substances to various environmental problems. For instance, the Global warming potential (GWP) corresponds to the climate change issue and it is evaluated by summing the quantities of greenhouse gases using weighting factors defined after the results of the International Panel on Climate Change (2001).

A general framework for the application of LCA in the building sector has been elaborated in the European REGENER project (1997) and the EQUER method has been developed according to this framework. This method is presented by Polster (1996). A building is described by a geometry, technical objects (materials, components) and processes (e.g. gas heating, water consumption, waste sorting,…). The heating and possibly cooling loads are calculated using the thermal simulation tool COMFIE (Peuportier, 1990). In a second step a life cycle simulation is performed using EQUER. Databases developed by the University of Karlsruhe (Kohler, 1994) and the Federal Polytechnic School of Zürich (Frischknecht, 1995) have been considered.

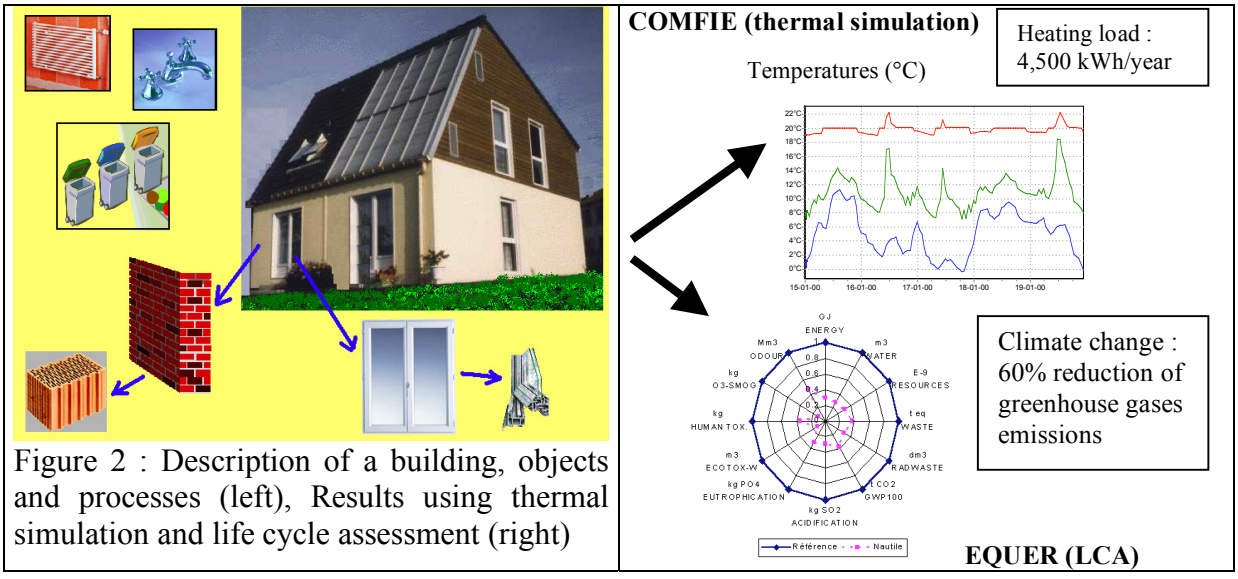

Figure 2 : Description of a building, objects and processes (left), Results using thermal simulation and life cycle assessment (right)

The renovated building has been modelled considering the different orientations of the rooms and separating the apartments situated under the roof, where the thermal losses are higher. A separate zone is considered for the stairways. The walls are constituted by 20 cm concrete. The facades include a high proportion of windows (nearly 50%). The standard renovation initially planned consisted in replacing the single glazing by double glazed windows, and insulating the walls with 6 cm glass wool. Several measures have been studied in order to improve the thermal performance of the building :

- increased insulation thickness,
- use of advanced glazing (low emissivity, argon filled),

- preheating of ventilation air in glazed balconies,
- moisture controlled ventilation.

The next figure presents the results of a sensitivity study : the heating load per m^2 is given for the building before renovation, after a standard and an improved renovation ; the insulation thickness is varied.

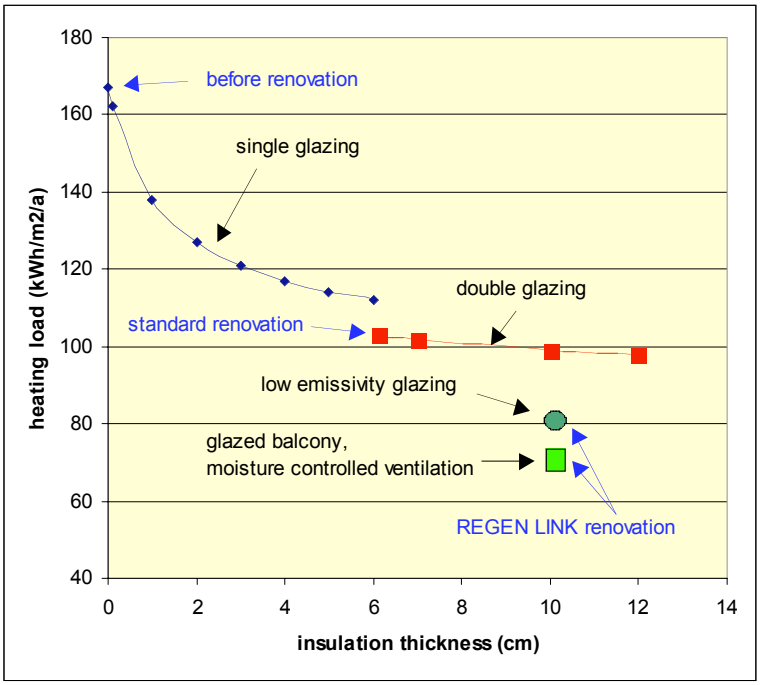

Figure 3 : variation of the heating load in terms of envelope characteristics

This graph shows that the first centimeters of insulation allow a large reduction of the heating load, but this effect is much smaller if the insulation thickness is further increased. The choice of the glazing type is very important. Low emissivity double glazing is used in this project, hard coating is chosen for south facades and soft coating in the other facades (hard coating glazing has a higher U-value but a higher solar transmittance factor, thus it is advised for south oriented facades).

The thermal calculations are complemented by LCA using the EQUER software. An example sensitivity result is given below.

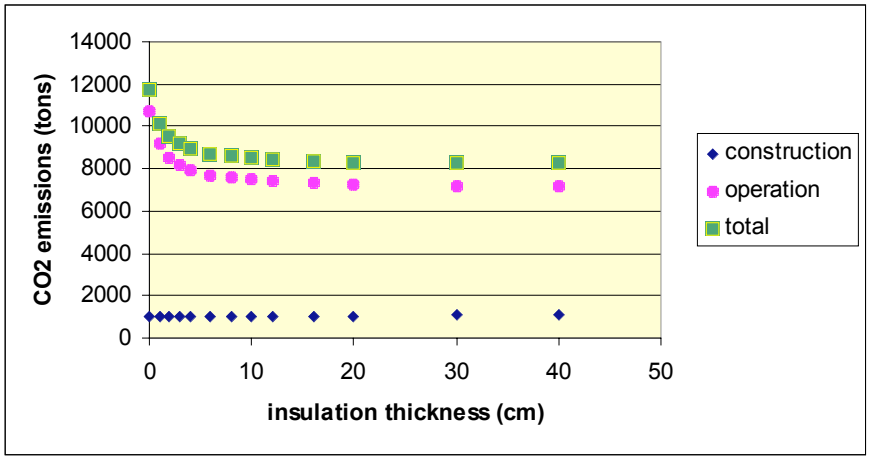

Figure 4 : example LCA result, CO_2 emissions in terms of the insulation thickness

The variation of the heating load induces a variation of CO_2 emissions corresponding to the operation of the building, accounting for the district heating system (the fuel being 50% coal and 50% fuel oil). The CO_2 emissions for the construction phase vary in a linear way in terms of the insulation thickness. The total emissions curve shows a flat optimum with very small variation from 10 to 40 cm. A value of 10 cm has been chosen for economic reasons : the cost of 1 kWh saved is around the cost of 1 kWh provided by district heating (cf. following table). This study shows that increasing the insulation thickness is not the most appropriate measure in our climate. Improving the quality of the glazing, preheating ventilation air and reducing the thermal bridges through the balconies seem more promising.

Table 1 : Economic data

Technique	Overcost (incl. VAT)	Estimated energy saving	Cost of 1 saved kWh	Cost of 1 ton CO_2 avoided
+4 cm insulation	13,500 euros	21,000 kWh/a	3.2 euro cents	84.6 euros
Low emissivity glazing	6,500 euros	82,000 kWh/a	0.3 euro cent	7 euros

The LCA study also shows how the renovation reduces the potential environmental impacts of the building. The following graph compared the indicators for the project before renovation ("Montreuil before"), after the standard renovation initially planned ("Montreuil reno"), after the renovation re-designed within the European REGEN LINK project ("Montreuil euro"), and the fourth case corresponds to the use of wood fuel in the district heating system. Each axis corresponds to one indicator. The case before renovation is considered as a reference and the indicators for the other cases are given in relative values (e.g. the CO_2 emissions are around 50% lower after renovation, 70% lower if wood fuel is used).

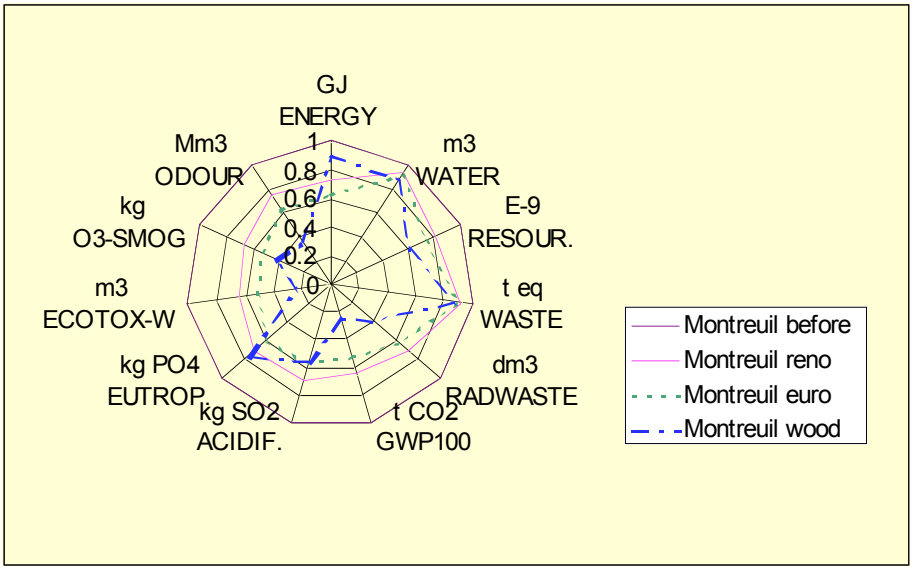

Figure 5 : reduction of environmental impacts by various types of renovation

A modification of the energy performance has a large influence on the life cycle impacts. The combination of thermal simulation and LCA allows an evaluation of the environmental benefit provided by higher quality components, taking into account their effect on the energy performance and the impacts related to the construction and demolition phases. Simpler energy calculations are in some cases not sensitive enough : the error on energy related

impacts can be larger than the difference between 2 materials. Another advantage of thermal simulation tools is the evaluation of the thermal comfort : both energy saving and thermal comfort must be achieved.

4. USE OF GREEN BUILDING TOOL

The GB Tool combines environmental criteria of a building with issues regarding its urban context. It is thus complementary with the LCA approach presented above. The environmental profile for the same building is given below, comparing the project before and after renovation. Like in the LCA study, the reference considered is the building before renovation. The criteria are rated between -2 and +5.

The renovation studied here concerns the building and not the urban level, so that most indicators are identical before and after renovation :

- the 4 storeys building is surrounded by empty spaces (sport space, greens and square), so that the land use per inhabitant remains high,
- the water use and effluent is typical, the area dedicated to waste sorting is low because no waste sorting is organized yet by the municipality,
- the ODS indicator (ozone depletion) is very high because there is no air conditioning, the material indicator is average (the renovation is better than a new construction but few recycled materials are used), the site impacts are limited, though the neighbouring buildings are sometimes shaded),
- the indoor air quality is average, the illuminance is very good because of the high glazing area, the thermal comfort is high because of the high thermal mass, solar protection and cross ventilation but the indicator is rather low because there is no humidity control (though measurements show that the humidity remains naturally within comfort conditions), there is no noise attenuation between dwellings so that the acoustic indicator is weak,
- the central heating system allows little individual control ; adaptability, maintenance performance and amenity are rather average,
- three indicators are largely influenced by energy (greenhouse gases -GHG-, energy and acidification) and are greatly influenced by the renovation.

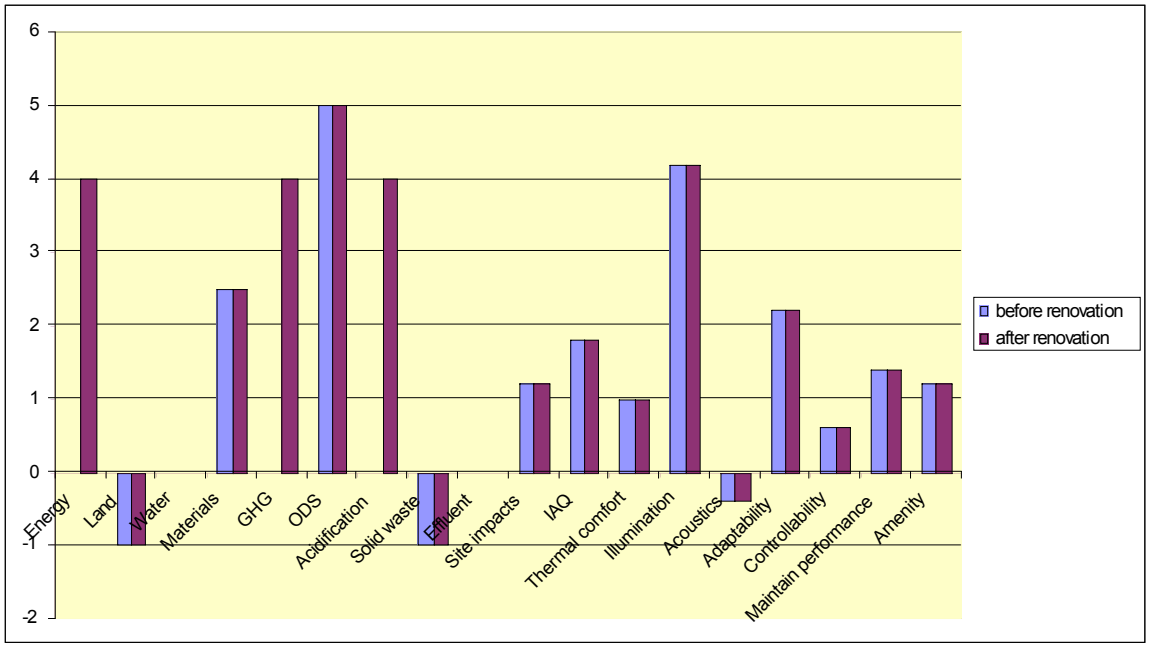

Figure 6 : GB Tool results for the building before and after renovation

5. COMMENTS AND CONCLUSIONS

The GB Tool is adapted to the objectives of the international green building challenge but it cannot really be used as a design tool : it is not sensitive enough to compare alternatives and to make choices. It includes issues related to the urban context, which cannot be influenced by decisions taken during the design of a building or a renovation project. Several tools should be developed for the different levels : decision making tools for the urban level, and design tools for the building level.

Some indicators may correspond to a specific context : e.g. in GB Tool controlling humidity is necessary to get a high score on the "thermal comfort" indicator, which may be irrelevant in some climates. Some indicators are more relevant for a new construction than for a renovation project. There is no indicator concerning radioactive waste, which would be needed in countries where nuclear production is not negligible in the electricity mix. Urban indicators raise the problem of their follow up : such indicators are useful if they can be regularly evaluated in order to measure the efficiency of an urban policy.

Rating the different indicators (e.g. between –2 and +5 in GB Tool) requires a precise assessment method, otherwise it is a very subjective process. The definition of a reference is needed for some of the indicators, e.g. a 2 score on the greenhouse gases emission indicator corresponds to 20% reduction compared to this reference. If a comparison is not performed using LCA, the score is likely to be arbitrary.

For this particular project, GB Tool has not influenced the decisions because it is not sensitive enough to design parameters. On the other hand, LCA and thermal simulation allowed to compare various alternatives and to make some choices like the insulation thickness and the type of glazing. Of course the decision process involved other aspects among which economy, technical know-how and habits of contractors.

The use of professional tools during the design phase, e.g. life cycle analysis, thermal and lighting simulation, acoustic calculations, contributes to improve the quality of a project. The results of these tools may be helpful in a discussion with the client to present advantages and drawbacks of various alternatives. The decision results from priorities given to different criteria, and these priorities should be defined through a local participatory process involving the professionals (client, architect, consultants, contractors,…) and if possible also the future users of the building.

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Prefabricated units of solid wood – an alternative to sustainability in the building industry

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1. INTRODUCTION

In the last 5 years, a lot of effort has been put into research and development of prefab units of solid wood in Scandinavia. In Europe, Germany and Switzerland have already a lot of experience and know-how on the application of solid wood units in modern constructions.

A large potential has been identified for the use of solid wood units. Research has shown that this product can be competitive both in regard to economical, constructional and environmental issues.

The forestry and sawmilling industry see the potential for increased timber utilisation, including low quality timber, timber that otherwise not would be utilised, or used in production of products with lower added value.

Contractors look to the new possibilities and advantages solid wood units represent in proportion to existing systems. Fewer layers, fewer work phases, lower weight, lower constructional height, flexibility and a better working environment are some of the positive effects experienced from using solid wood units. (Kristensen, T. 1999)

Solid wood prefab units are made from laminated boards that are joined together with pre-stress wire, wood pegs, nails or glue. Some of the solutions are shown in figure 1 and 2.

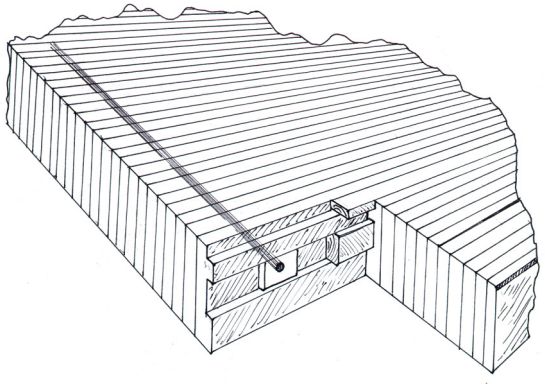

Figure 1 - Example of a prestressed unit

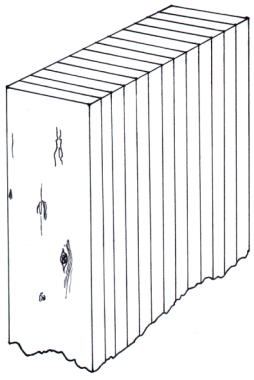

Figure 2 - Glued unit, glulam

There are many applications for prefab units of solid wood. They are mostly used as floor partitions in houses and office buildings, in galleries and in balconies. One of the more exciting applications that have been developed is the use of solid wood units in light parking structures. Many sites stand unoccupied for 10-15 years before anything is built on them. The idea is to put up a strong, light construction, which can be moved when more permanent plans

are ready for the site. Another application is timber bridges, where solid wood units are used in the bridge deck.

Figure 3 and 4 show some of the applications of units of solid wood:



Figure 3 - Mounting a balcony of solid wood units (Trätek/Ryga AB)



Figure 4 - Mounting floor partitions of solid wood units

2. SUSTAINABLE BUILDING AND BUILDING MATERIAL

Building with wood has always been considered as a sustainable way of building in Scandinavia. Wood is natural. It is a renewable material. It is easy to manufacture and process, resulting in low energy use at factory and construction site, and it is a strong material, relative to its weight.

Wood is also part of a natural cycle. CO_2 is released through decomposition/combustion and taken up in biomass through photosynthesis. Wood is therefore considered to be CO_2-neutral.

2.1 Case

The purpose of the study has been to gain knowledge about environmental aspects of building with solid wood units.

The functional unit has been identified as "supplying a construction with a 1 m² non-apartment dividing floor for 60 years". The product system includes, amongst others, forestry, sawmill, unit-production, construction, demolition and waste handling.

2.2 Energy and resource issues concerning prefab units of solid wood

Kristensen, T. (1999) produced an LCA of prefab units of solid wood. Figure 5 and 6 show the use of resources[1] and utilisation of energy[2] in the case study, and it is obvious that the consumption of renewable resources and energy is the dominating factor. This indicates that the use of solid wood units can contribute to more sustainable building, where we see a transition from consumption of non-renewable to renewable resources.

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[1] Also includes energy resources. The timber consumption has been calculated as dry substance. The scarce non-renewable resources used are crude oil, uranium and natural gas.

[2] "Solar energy (fuel)" is the lower heat value for biproducts (internal use). "Solar energy (feedstock)" is solar energy taken up during the photosynthesis (still present in the product system after the allocation) minus "solar energy (fuel)".

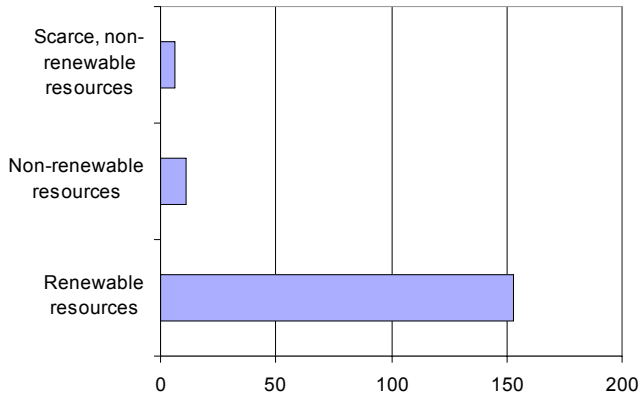

Figure 5 - Resource consumption in case study [kg] (Kristensen, T. 1999)

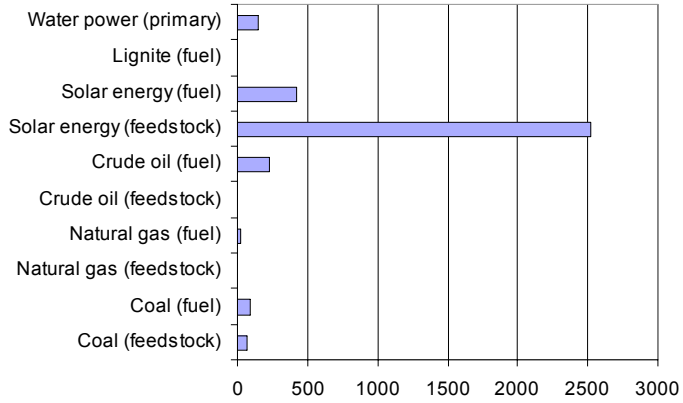

Figure 6 - Consumption of energy and energy resources in case study [MJ] (Kristensen, T. 1999)

Petersen, A.K. & Solberg. B. (2001) examines the energy consumption of the life cycle of beams in laminated wood. The investigation show that if wood is burned after 50 years, it generates more energy than what was consumed in the manufacturing phase; i.e. more energy is generated from burning the unit at end of life than used during production.

2.3 Carbon storage of solid wood units

Storage of carbon in wooden materials is a short-term perspective in proportion to natural storage in coal and oil reservoir. But this intermediate bearing of CO_2 in wooden materials can be a useful tool in the climate-perspective, as it can win time to come up with even more powerful and permanent efforts to balance the greenhouse gases. Solid wood units are products with a relatively long life span and can serve a role as an intermediate bearer of CO_2. Intermediate bearing of CO_2 in products is therefore expected to be included in the international climate agreements from 2012-2013 (Berge, B. 2002).

Figure 7 shows the balance in the potential contribution to GWP. The CO_2 emissions from the combustion of fossil fuels during production are less than the amount stored in the unit.

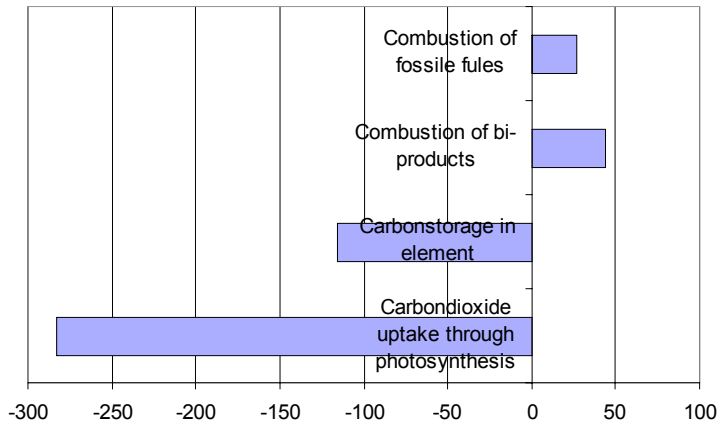

Figure 7 - Global warming potential (GWP) in [kg] (Kristensen, T. 1999)

By substituting high emissions products with solid wood units, the contribution of greenhouse gases from the construction industry will decrease. The use of energy on construction site will also decrease if heavier materials are substituted with solid wood units.

2.4 Recycling and reuse

Prefab units have a unique potential for reuse. Few layers and materials make it relatively easy to utilize used prefab units in new constructions. Glued units can be adjusted to new dimensions with simple tools and used in other constructions. Removing the nut or cutting the bar can release plank in prestressed units, recycling the iron bar and reusing or recycling the plank for several purposes.

At end-of-life, wooden materials can be recycled as raw materials for board manufacturing or recycled for energy purposes. The energy potential can be quite considerable when using solid wood in the construction. A 200-space parking structure made of solid wood units and glulam has an energy potential of 1 000 MWh, equivalent to the yearly energy demand of 40 private houses in Sweden with electrical heating (Svanaes, J. 2002).

3. RELEVANT PROJECTS

A detailed LCA on solid wood units is currently being investigated and will be published in July 2002 as a part of the Nordic Wood project-programme "Building with solid wood units". This project identifies many aspects around solid wood units, and will be presented in several specific reports, covering environmental, strength, moisture, fire, architectural and constructional issues.

A comparative LCA investigating solid wood units vs. concrete units for a specific building project will be presented. This will be a far more detailed investigation than what has been presented in this paper.

4. CONCLUSION

Solid wood prefab units can be a useful supplement to sustainable building. The unit has low weight and uses little energy from non-renewable resources, contributing to a low non-renewable energy use, and low CO_2 emissions, in the total life span. If the energy content of the units is taken into account, the total use of energy from building with solid wood units is negative; i.e. more energy is generated from burning the unit, than used during production.

Solid wood units have a huge potential for reuse, recycling and energy recovery.

The issue of biological diversity has not been discussed in this paper. This is an issue that probably will depreciate the sustainability of solid wood units. But by using timber from certified forests, the signification of biological diversity will be less significant in the total environmental inventory.

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Research into Building for Sustainable Development. Experiences from a Swedish cross-disciplinary program, "MISTRA Sustainable Building"

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1. INTRODUCTION

The problem area of sustainable building is important and complex. Research in the field is being carried out world-wide. It is well-known that many findings from ongoing research are not used in practice although they are available. Therefore, the aim of the program "MISTRA Sustainable Building" is to develop knowledge and know-how for the promotion of sustainability in design, construction and maintenance of buildings, and to facilitate for the findings to be implemented in practice. The program has been underway in the form of approximately fifteen Ph.D. theses, from three different universities, for about six years. So far, results have been published in articles and theses, and the final outcome, a holistic evaluation of the program is ongoing. This paper is the first result of one part of that evaluation comprising interviews with the participants meant to present the experiences of a large group that has worked together for a long time, i.e., results that most often cannot be read in articles and reports. Focus is set on the relation between the individual subprojects and the joint program and how experiences can contribute to constructive proposals for coming programs.

2. AIM AND DESIGN OF THE STUDY

2.1 Objectives

The program "MISTRA Sustainable Building" is, in a Swedish context, a pioneer venture in terms of scope and ambition, which makes it important to evaluate. The aim of the evaluation is to give a holistic view comprising the research results and the experiences of the participating researchers (Edén & Jönsson eds.). The objective of this paper is to present a part of the evaluation, opinions from the participants concerning the added values when working in a program and the possibilities reach the overall aims given by the program founder; namely implementation and inter-disciplinary research of the highest quality. The program plan uses the word "cross-disciplinary", but since "inter-disciplinary" is a more frequent denomination, and the meanings are roughly equal, we use "inter-disciplinary" in this paper.

2.2 Method

The method is similar to an internal evaluation, aimed at other groups who work within the same field (Karlsson). The interviewers have participated in the program. Criteria for the

evaluation have been discussed with all participants and the design of the study has been elaborated in the research group in a series of seminars.

The interviews have followed the program organization levels: 1) A board representing stakeholders. 2) A leading group of coordinators including the program manager, who also has supervised approximately half of the Ph.D. candidates. 3) Additional supervisors of Ph.D. candidates in different sub-projects. 4) Ph.D. candidates, who have carried out the research in individual subprojects. 5) An international advisory group. Interviews with the coordinators have been carried out personally. The Ph.D. candidates have given their answers in two seminars, which have been recorded. Supervisors and members of the board have been interviewed by phone. The advisory group has not been interviewed, since they were most active in the initial phase or the program. The final manuscript has been reviewed by all interviewed, with the opportunity to make corrections or complementary additions.

3 RESEARCH FOUNDER AND PROGRAM

3.1 MISTRA

The Swedish Foundation for Strategic Environmental Research – MISTRA - aims to support research of strategic importance for a good living environment. Criteria for a MISTRA program is that the leading national expertise is gathered, and that co-operation between universities and institutes is established. A program shall provide the latest scientific findings "irrespective of sectoral boundaries" to stakeholders, and furthermore provide the research community with problems formulated in practice (MISTRA).

3.2 MISTRA Sustainable Building

The MISTRA program "Sustainable Building" was started in 1998, and was one of the earliest to be launched. In 2003 the program will be finished together with the last Ph.D. projects. The aim of the program was formulated to "develop knowledge, methods and know-how for the promotion of ecological sustainability, environmentally sound actions and an Eco-cycle system in design, construction and maintenance of buildings, and to facilitate for the results to be implemented in practice" (Sustainable Building). Eight departments from three universities and one research institute have been involved. In all, fifteen doctoral candidates and twelve supervisors, including the four coordinators, have co-operated.

3.3 Findings

So far (April 2002) the project has resulted in about ten theses in different areas and some joint articles (MISTRA BYGG). However, the aims, the number of institutions and persons involved in the program has offered many novelties even for experienced researchers. Experiences from the daily work under these conditions cannot be read in theses or articles, but are also important findings.

4 INTERVIEWS

4.1 Implementation

4.1.1 In general the most striking answer, also from the board, is that stakeholders in the Swedish building sector do not read scientific papers (least of all those written in English.)

4.1.2 The Ph.D. candidates have a broad variety of experiences in terms of interest from the surrounding world, from regular contacts to none The most common way of external communication is lectures, both public and within the educational system, followed by

articles in specialized press. The Ph.D. candidates would like to intensify external communication if the prerequisites were given, i.e., time, resources and university credits. Their experience is that the conditions in this program do not differ substantially from those of other Ph.D. candidates: Scientific articles and a thesis are all that count. As a Ph.D. candidate you also want to have reached some security in the results and personal confidence before meeting the external world.

4.1.3 The coordinators mean that 'immediate implementation' is easier to say than to do. You cannot foresee exactly when or for whom findings will be relevant. As a first priority, they decided to aim at the production of doctors with high competence in sustainable building, to act within the industry in future as specialists and intermediaries between practice and scientific research. As a consequence, the problems treated by the subprojects had to be of scientific interest in order to be acceptable Ph.D. subjects. In most cases, some adaptation would be needed for the results to be implemented in practice. Public seminars and information meetings have been carried out with success. The closest channel for implementation is still the university educational system. Perhaps more efforts could have been invested in continuing education, and perhaps the stakeholders could have given more support for such activities. One respondent says that the building industry sometimes is reluctant to listen to results that criticize established perceptions, and that there is still a latent conflict between business and environmental commitment among the stakeholders.

4.1.4 The supervisors point out that there is a difference between direct implementation and implementation through existing educational structures. Many of the subprojects are very well suited for learning activities in the building sector or continuing education at universities. One view is that the program has a traditional view of “implementation” as one-way communication of results. Another view is that if direct implementation is an important issue, problems have to be identified in regard to different user situations.

4.1.5 The board means that the sub-projects are more directed towards other researchers than towards practitioners. However, the industry must make more efforts to transform results into practice. One respondent mentions the risk when you work in close contact with the industry, and reach results that are contradictory to dominating priorities. The immediate reaction can be counter-criticism or deafness. From a long-term perspective the results of this program will be useful, but the greatest impact is the production of Ph.D.s.

4.2. Inter-disciplinary aspects

4.2.1 In general, all respondents mean that the exchange and deepened understanding of different scientific approaches has been an important effect of the program.

4.2.2 The Ph.D. candidates point out that joint courses in the initial phase were of great importance, and one respondent means that the amount of courses was not enough. The internal contacts, though varying, have been highly appreciated, but many of the regular meetings focused too much on ”information” and too little on “exchange.” The students state that uncertainty in the beginning of a project must be overcome before you can start discussing your results with others. The time schedule has also hindered efficient exchange. One project was intended to provide others with data, but since these projects started at the same time, there was too little to deliver when it was needed elsewhere. Within the group, there is a sharp line between those who make definite distinctions between “research” and “development,” and those who could try new forms for crossing boundary, for example, in close co-operation on problems set by external practitioners.

4.2.3 The coordinators mean that Ph.D. candidates first need training in one scientific tradition, from which they can learn to understand the existence of a variety of disciplines and ideals. The program has succeeded fairly well. Students have met in seminars "without regard to disciplinary boundaries" and have gained respect for each others' work. One opinion is that this is one of a few programs, in which different universities have established respectful co-operation. As regards the exchange of findings, it is an advantage if all subprojects start at the same time, in this program some were delayed in the beginning.

4.2.4 The supervisors mean that inter-disciplinary is a word often used without any cover. Their opinions represent two views. One is that research problems shall be clearly defined and limited. The other is that if problems à priori are ill-defined, as for example environmental problems, science must dare to try new forms to elaborate them. From that perspective, the program has been "only" multi-disciplinary and the outcome is an anthology, although very successful concerning internal communication on scientific and personal levels.

4.2.5 The board has a vague perception of the sub-projects and their results. Their view is that the program is a little bit scattered. One respondent says that the approach has been entering a field rather than formulating a guiding hypothesis.

4.3 Added values

4.3.1. In general, the program has produced researchers with wider perspectives, broader capabilities, and a more relevant network than a set of independent projects would have done.

4.3.2 The Ph.D. candidates all mean that they have gained personally by being part of a program. For some of them, their sub-project also has benefited, for most sub-projects it seems to be neutral and, one person claims that the sub-project has lost in depth and quality (Table 1). For many students, it was important to know that they were entering a program and not only a project when they applied. Membership in a group was both reassuring and stimulating.

Table 1 Matrix showing six possible positions. The ellipse covers the cluster of Ph.D. opinions in the "MISTRA Sustainable Building" program.

Project / Person	Enriched	Equal	Weakened
Enriched			
Equal			
Weakened			

4.3.3 The coordinators mean that the program as such has been a strength when contacts have been made with other research institutions. They made the decision build up the program on a bottom-up approach based on existing competence. Scientific co-operation has to grow through labor, especially if there is a dimension of sharing or understanding fundamental values. The candidates has grown to independent, enlightened and experienced researchers, which was a goal. Perhaps the supervisors could have been engaged more in the joint activities.

4.3.4 The supervisors mean that they have had an unclear position regarding common activities and their commitment has varied. One person sees no real added values in the program. One means that the program has shaped a platform for coming research, and that some sub-projects would probably not have been funded through the regular system. The existence of a protective program has allowed open and explorative approaches.

4.3.5 The board has had no real contact with the candidates or the supervisors. They can see no obvious connection between subprojects. Some subprojects would perhaps not have been launched in regular procedures.

5 DISCUSSION

5.1 The privilege of defining a problem

It is evident that both researchers and practitioners must learn from each other. Practitioners must realize that research cannot be expected to deliver ready made, just-in-time answers. Learning is necessary and calls for time and efforts. Scientists must realize that dissemination calls for more than writing articles. Building is a complex process, and each building project offers its own combination of discipline problems. The responses indicate that the stumbling block concerning both implementation and inter-disciplinary aspects seems to be the tension between "relevant" and "scientific" problems. Instead of adding a person to mediate the research results of a program, a research group could try to choose problems from practice and to compose an adequate set of subprojects around cases. A case can give a context where researchers can meet, thus contributing relevant results from different disciplines and also redefining the research problems, according to the contextual prerequisites. The stated gap between research and practice, i.e., that available results are not used in practice, could in such a program be analyzed, for example, whether it depends on a discrepancy in problem definitions or in insufficient methods of mutual learning. Such an approach is not uncontroversial. The optimism and skepticism revealed in the responses from both professors and Ph.D. candidates is a reflection of the surrounding scientific climate.

5.3 Theme and focus

Inter-disciplinary research can be regarded from two perspectives. One is a process aiming at integration between disciplines, the other a process aiming at an intellectual exchange between researchers. A process aiming at integration requires a lot of work and a lot of time (Tengström). A sensible ambition for research into "sustainable building" would be to gather around external problems, establish co-operation between disciplines and reach a multidisciplinary understanding. The quality of the results, in such an approach, would be determined by the extent to which "solutions" relevant to practitioners can be reached, and not the long and difficult process of achieving integration between disciplines. What is needed is a theme, and a focus within the theme. From the interviews you can see that "Sustainable Building" could function as a theme. The statements that "MISTRA Sustainable Building" appeared "scattered" show the difficulties to find a focus. The program did have a focus, on energy and material flows, omitting for example indoor climate and water use, and still the subprojects could have been more inter-connected. What can be tried in new programs is whether "place", "case" or "project" could be a more clear focus.

5.3 Mentorship

An approach in which Ph.D. students are expected to handle ill defined, "real" problems in co-operation requires supervisors that are not only open for collaboration, but that accept that

such problems will lead to methods and results of another kind than those the established ideals prescribe. Even if Ph.D. candidates need a platform in a discipline, a "real" problem means that they have to build bridges together *between* disciplines. An exchange of opinions and respectful co-operation needs, at the very least, strong support from the supervisors, preferably from supervisors who have tried and know what it means to leave one's solid platform. One of the more important tasks for the supervisors is to find a network of peers who have an understanding of research across boundaries and can review the outcome of inter-disciplinary attempts in regard to non-established prerequisites, not only parts of the outcome from established ideals.

5.4 Timing and organization.
A systematic exchange of results produced "in progress" needs both an organizational plan and a sense for improvisation (compare the opinions from Ph.D. candidates and coordinators concerning when projects should start). That which has been successful in the program is the systematic use of information meetings and regular reports, though many of the Ph.D. candidates and their supervisors have complained that this took too much time. Other fundamental means are series of seminars about papers in progress, common courses, also for mentors, and, in addition to planned actions, careful observation of the possible opportunities for co-operation that occur during the process. Co-operation does not come automatically, especially if it comprises understanding fundamental scientific criteria from other disciplines. The process must be given time, resources and university credits.

6. HYPOTHESIS

One hypothesis can be made from the evaluation. It is that "relevance" can be seen as a criteria for "scientific quality" concerning " research into sustainable building " and even "building research in general". Of course, such a hypothesis raises new questions like "relevance for whom, when and where"? What can be stated is that many major aspects call for co-operation between disciplines and contacts with practice in order to be understood and handled, which is a support for establishing programs. Within these, you can find research problems that can clearly be defined and carried out using established methods.

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Environmental status of buildings
New features in the Swedish system for environmental auditing and assessment of buildings

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INTRODUCTION

The demand of information on environmental aspects of buildings is still increasing. More and more people want to know whether a building is good for their health or not and if it fits into a sustainable society. For example:

- *the property owner* wants to know in order to declare the environmental status of the building
- *the property manager* wants to know for the planning of operational maintenance
- *the tenant* wants to know whether the environmental requirements imposed are met
- *the financier* wants to know whether the security is affected by an environmental liability
- *the insurer* wants to know for the purpose of risk assessment and loss adjustment
- *the buyer* of a property wants to assess the environmental risk with an Environmental Due Diligence

A group of building owners have therefore in cooperation with consulting companies developed a system for environmental inspection and assessment of buildings - **The environmental status system**.

The development of the environmental status system started in 1995. The system was taken into operation in April 1997 as a practical tool for the facility management of buildings. Version 4 of the system was launched in January 2002. Up to now about 15 000 000 m^2 have been inspected. About 600 people have been educated and obtained their licence to use the system. The system has been widely used and received full acceptance within the real estate sector.

The new 4th version includes:

- A revised indoor environment part with a questionnaire
- A new module for aspects on land, especially aimed for Environmental Due Diligence
- A new part designed in order to take note of environmental aspects from tenants
- A new layout of the programme that is designed to make it user-friendlier.

This new version of the building audit system is an important step forward which will make the method much more useful for the 35 members of the Association for Environmental Status of Buildings.

DESCRIPTION OF THE MODEL

The environmental assessment covers about 90 questions related to the environment (so-called environmental aspects). The questions are divided into four main groups:

Table 1. Environmental aspects covered by the assessment

Main group	Number of environmental aspects
• indoor environment	46
• outdoor environment	8
• energy	6
• natural resources	29
• Total	89

During auditing, each environmental aspect is classified in a 5-level response scale.

5. Sound environmental choice throughout
4. Sound environmental choice in parts
3. Normal requirements
2. Unknown – needs further investigation/Bad in parts
1. Bad

Class 3 corresponds to normal requirements, class 5 to sound environmental choice.

Normal requirements	Requirements in standards or practice
Sound environmental choice	A conscious choice with higher environmental requirements than normal requirements

There are extensive instructions for the environmental status model with a description of each environmental aspect, its occurrence, how identification, classification and testing are carried out and with examples of measures and references.

PERFORMING AN ENVIRONMENTAL AUDIT

Before the audit, necessary information is collected describing the property and the operations it houses.

The audit is primarily visual but often also includes simple measurements of VOC, formaldehyde, air change effectiveness and radon. Where necessary it is supplemented by questionnaires and further tests.

All audit questions have the same degree of importance, i.e. are given grade 1. However, it is possible to adjust the grades and give high-priority environmental aspects a higher degree of importance. The audit results can be summarised into main groups and sub-areas. The Environmental Status Model contains the following main groups and sub-areas:

- Main group INDOOR ENVIRONMENT with sub-area AIR QUALITY
- Main group OUTDOOR ENVIRONMENT
- Main group ENERGY

- Main group NATURAL RESOURCES with sub-area ENVIRONMENTALLY DISTURBING SUBSTANCES

ENVIRONMENTAL REPORT

The results of the audit are fed into a database and processed to form an Environmental Report in which the results are compiled in text and in a series of graphs, so-called environmental roses, which describe the environmental status of the building. The report leads to a proposal for concrete measures that can be built into the management plan.

The Environmental Status Model thus provides a basis for adapting property management to the environment and constitutes part of an inventory prior to the introduction of an environmental management system.

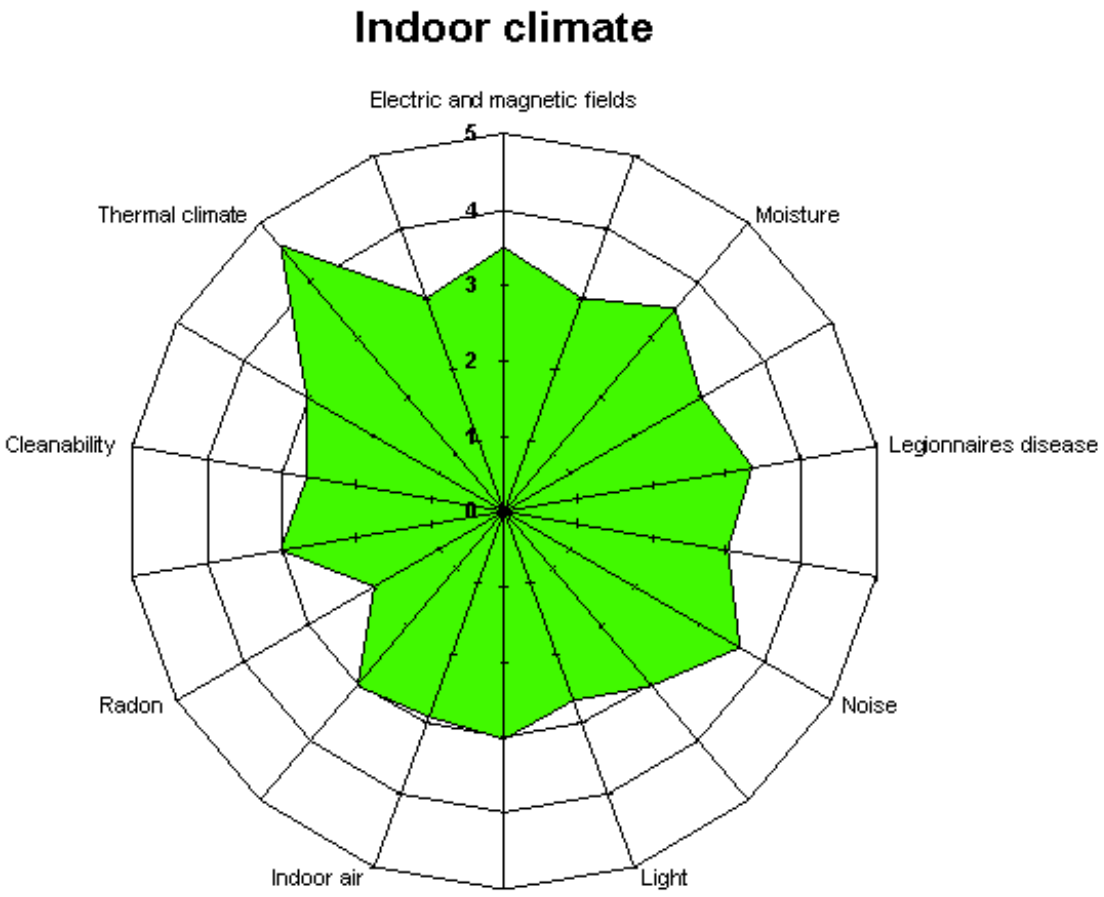


Figure 1. For each main group and sub-area an Environmental Status Rose is presented. The larger the rose is the better is the Environmental status

APPLICATONS - EXAMPLES

List of estate stock

The computer program includes the possibility to compile data for a real estate stock. The mean value can be created for the stock and compared with the highest or lowest environmental class for the respective environmental aspect in the stock. Comparisons can also be made between a certain property and the rest of the stock.

Establishment of goals
To help in the maintenance planning for the property or stock, goals can be established for the respective environmental aspects. The environmental class that needs to be attained is entered together with current measures for achieving the goal and the calculated cost. Goal roses can then be printed out showing the current status as well as the goals. All proposed measures for achieving the goals can then be listed and included in the Management Plan.

Housing declaration of environmental performance
After an audit has been made of a housing property, the results can be used to make a declaration of the environmental performance.

NEW DEVELOPMENTS

Revised indoor environment part with a questionnaire
The revision of the indoor climate part has encompassed:
- revision of old questions,
- a few new questions,
- one simple questionaire for dwellings and one for offices
- new layout for the declaration to the tenants
- new illustrations to better explain the questions to the assessors

New model for aspects on land
Environmental aspects concerning land and the risk for contaminations play a very important role in assessing a building. It is often the dominant environmental aspect when a building property is bought or sold. The land model is especially aimed for the first step in an Environmental Due Diligence.

The land model consists of 14 questions with subquestions that assess the risk for contaminations without doing any site tests. The answers to the questions are assessed in a scale from 1 to 5 as the other environmental aspects and will indicate if further investigations are necessary. If that is the case proposals for further measures will be given.

As an example one question is about the type of heating system the building has had, the precautions that were taken in order to avoid spreading and contamination of the surrounding ground with oil leakage.

New part for environmental aspects from tenants
The tenants have a great influence on the environmental performance of a building. To have a holistic view a new part for tenants has been developed. This part includes about 50 questions concerning environmental management system, procurements, the consumption of different goods, waste, the consumption of water and energy, transports and communications, indoor climate and cleaning of the spaces.

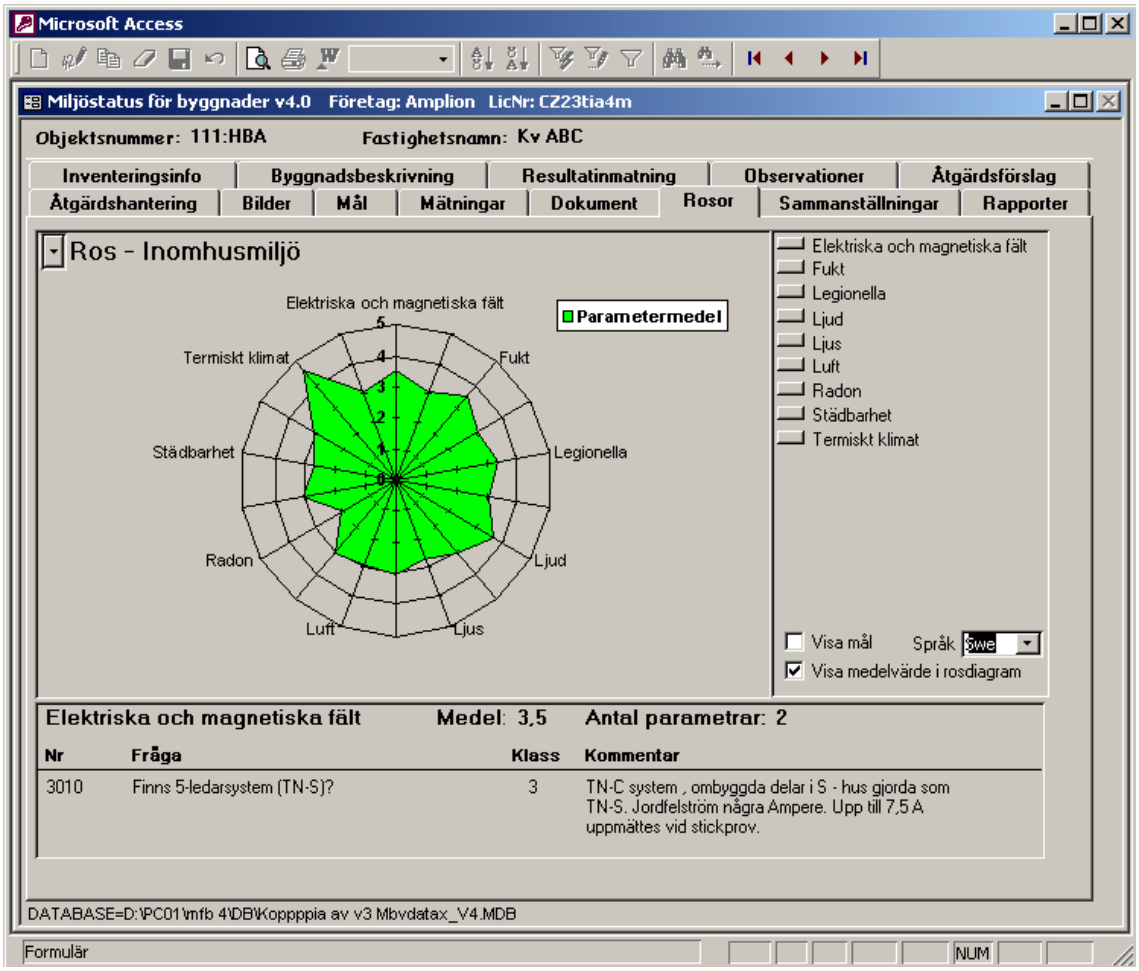
The tenants can use the environmental status i different ways, e g as a checklist and documentation of their environmental work, as a part of their public promotion and to formulate requirements on the performance of their deliverers.

The environmental status for the tenants is also a valuable complement to the environmental status for the building. Often the property owner and the tenants can cooperate to find the best

environmental solutions, e g concerning energy savings, and both parties can have a part of the gain – a win-win situation.

New layout to make the program user-friendlier
The MFB version 4 program has a new tab based user interface, which gives the user an overall view of the different parts of the program. Other new features are:

- Possibilities to make the report part of the inventory within the program, earlier made with MS Word
- Facilities for maintaining proposed measures
- Improved facilities for import and export
- Report generator linked to MS Excel
- It is now possible to see the roses and the figures behind them directly in the program



TRAINING AND COMPETENCE

In order to establish credibility and to achieve a sound and even quality in the use of the Environmental Status Model, the auditors shall have basic competence within their technical spheres and be well trained in the use of the model and approved by the environmental status group.

FURTHER DEVELOPMENT

The Environmental Status Model is being developed on the basis of the members' requirements. Close cooperation is maintained with the national project on the environmental evalua-

tion of buildings, EcoEffect, and with our neighbouring Nordic countries. The Environmental Status Model will be developed in harmony with the latest findings of these research projects.

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Sustainable Housing Design for the 21st Century

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1. INTRODUCTION

UN projections show that between 2020 and 2025, the worlds population shall more than double in size from 2.4 billion(1995), to 5 billion. The proportion of this population that is expected to be urban is proposed to rise from 47% to over 61%.(P. Hall, U. Pfeiffer, 2000) To corrospond to these demographic milestones, some 3.8 million new homes are proposed to be built over the next twenty years in the UK.

Taken as a whole, the collective impact of these houses in respect to their environmental, economic and socially sustainable resources has potential detrimental effects if housing continues in the same nonchalant direction. The direction we refer to, the associative materials, typologies and methods of procurement, derive from past cultures and lifestyles and to a large extent, have little comparison to the atypical social landscape of the 21st century, and the very different lifestyles we now lead.

2. CITIES

Relating to these two demographic milestones, many current issues regarding how we live in, use and work in cities are being asked and debated throughout the world, but do we need to readdress the larger picture in respect to how we perceive cities? What is a city and what does being attached to a city mean as we have left the novelty of living in a new millennium behind and begin to seriously address the issues surrounding how we live, or will be living in the future.

What makes a city ‘a city’, is the sheer density of people residing in one area, living working shopping and being entertained. The role of the city in this sense was to reduce the logistical costs of living. Over the centuries, cities have transmogrified, shaped by their own individual characters and regional settings to become almost self propelling machines of consumption. In short they have reduced their inhabitants down to consumers. City centers that were once vibrant and full of social activity were replaced by offices and shopping centers, reducing their daily role in the city by half as these spaces, not being occupied at night, became spaces of anxiety, borders which many of the cities inhabitants were afraid to cross at night.
As the inhabitants of the city were dissipated, the cities footprint grew turning valuable green belt land into suburb or endless roofs of social housing.

2.1 Kingston-upon-Hull

Before the second world war, the city centre was a bustling social space, but as housing was either cleared or destroyed, new estates emerged to the north, east and west of the city. The result was that the city rapidly began to spread. This demographic shift saw these areas divided into the common phenomenon of popular expensive suburbs and council estates full of the social problems on any such area in England or Europe. How then should such issues be addressed?

Kingston-upon Hull, like most northern cities in the UK has suffered economically from the industrial decline in the latter half of the twentieth century. High rates of unemployment and a declining river industry have seen many of the cities areas neglected in addition to the outer estates.

2.2 Future Strategies

Hull has a unique advantage in securing a strategy for the future. It is in the position of part owning its own telecommunications network. Part owned by the city's council and part by Kingston Communications, initiatives have been put in place to take steps in developing a regeneration strategy which aims to propel Hull as a cutting edge city and in the top ten in the UK. In the next few years some £40 million will be invested in ADSL connections to some 110,000 homes in the region, creating a community network broadband connection opening up new possibilities.

As the cities emphasis is changing from industry to one of learning and research, the identification of the challenges and unique possibilities which lie ahead have been formed from a partnership between the city council and the Centre for Regional Studies (CCRS) who have laid out key areas in;

- Falling population levels.
- Above average social deprivation.
- Lack of quality housing/ High percentage of rented properties.
- Poorly skilled local labour market.
- Depressed local economy.
- Low education and training aspirations.
- High crime rates.
- Poor health levels/ High mortality rates.
- Increasing traffic pollution and congestion.
- Poor support and leisure facilities.

To combat such issues the city has taken on board a strategy of reincarnation as opposed to the more restrained regenerative policies. This is reflected in what can be called the 'Digital City Programme' (DCP).

The DCP takes advantage of Hulls position in the telecommunications field, pushing the boundaries of technology and its connections to create a viable feature of its future strategies. This has been taken forward as a genuine sustainable regeneration strategy by the 'digital city task group' who is charged with the responsibility of achieving this vision. It has drawn up its own set of objectives to achieve this which include;

- Integrating the opportunities and practices of information technologies into the current and future life of the city.

- Transforming the economy, business and employment to create a prosperous economy in line with the information age.
- Create an intelligent knowledge driven city.
- Include all citizens and communities in the opportunities for a prosperous, healthy, safe and sustainable quality of life.
- Become a beacon for good governance, participation and public service development and delivery.
- Apply information and communication technologies to innovate, pioneer and modernize.
- Fulfill Hulls unique opportunity to benefit from the information age.

To realize these propositions, the objectives of the task group need to be incorporated into 'live' projects. Already many projects, epitomized by the newly opened 'Deep' with its business and research center by Sir Terry Farrell, has become the first stepping stone to an economic regeneration along the 'heartlands,' a once deprived industrial area along the river hull corridor set in the old center of the city. It is envisaged that the development of a digital creative industries cluster/ development zone as a project for the heartlands would not only feed and supply the city wide interactive television initiative, but also has the potential to create dynamic live/ work environments that could physically anchor a social livelihood back to the city's center.
Within these innovative clusters is the question of how should these new homes reflect such an experimental technological lifestyle? How could the old typologies, if at all, fit into these new clusters? Or would the creation of a totally new house typology be required for the atypical social landscape with its more diverse lifestyles?

3 TYPOLOGIES

The design of housing has become central to the debate on the future development of cities. The pressure to provide more affordable housing relatively quickly has seen many new developments in materials and methods, the emergence of modular construction forms and new ideas about the spaces in which we live in our towns and cities.

3.1 Flexible Building Systems

The issue became more apparent in the closing decade of the last century about flexible buildings, especially in housing, in relation to a viable environmental consideration, especially with regard to the concept of lifetime housing. It is established that more traditional house-building methods incur large costs and timely interruptions during construction, renovation or additional work as many try to adapt their houses to meet their own or changing lifestyles. A home suitable for one family's lifestyle can be totally unacceptable for another. In addition, the separation, or increase in a families circumstances create a new set of considerations and spacial requirements. It has become an accepted fact that we no longer live by a static set of conditions on which past typologies were built. Families change and the need to change our own environments on an increasingly regular basis has seen the emergence of innovative construction methods and levels of detailing.

One such project which has incorporated such issues is the modular housing scheme in Murray Grove, Hackney, London, by the architects Cartwright Pickard (yorkon 2001). The scheme aims to deliver affordable housing to key workers in the city, many of whom cannot afford to live relatively close to their places of work, and like so many city workers are being pushed further from the center of our cities. The modular living units comprise of two or three sections which have the ability to easily change their internal layout from a suitable

environment for a young couple with a small child, to an arrangement which would suit up to three young people sharing in a bed sit arrangement. This is done at little cost and disruption to the occupier making it increasingly possible for a living environment to adapt more quickly to social need and circumstance.

In addition to the more obvious economic benefits, planning for future change in this way would mean that a person could live in the same house through many different and often unexpected changes that they might incur in their life. This issue of 'lifetime' housing, closely related to accessibility in buildings, has been brought to the forefront of the housing issue by the introduction of part M (approved document Part M, Building Regulations, 2002) of the regulations in the UK, and grown to form a major area in rethinking housing. By contrast, old typologies, consisting of bricks and blocks arranged in semi, detached or terrace formations resemble a static and somewhat inflexible culture of lifestyles past, when there appeared some 'unwritten protocol' of how family life was arranged and carried out. Such types based on special requirements attached to set living patterns and functions such as kitchen, living room, bedroom, drawing room, sitting room etc resemble little of the daily programme in this century.

3.1.1 Accessibility and Flexibility. During the 1990's the governments decision to extend Part M (especially in relation to Part L regarding the conservation of fuel and power) (approved document Part L, Building Regulations, 2002) of the building regulations to cover housing came from such issues regarding how we live, and the considerations for a wider section of the public including elderly and handicapped people. Part M deals with accessibility and was formerly used predominantly in the design of public buildings. These regulations came into force in 1999 and in addition to covering accessibility, they attached to this concept of 'lifetime housing,' aiming to 'build-in' flexibility which may make it easier for a person to adapt their home as their social circumstance changed. The idea of adaptable housing is widely acclaimed on the continent and can be found in many European countries including Finland, Greece, Italy, Spain, Sweden, Switzerland and the Netherlands. The criteria for lifetime housing is different from country to country, although extensive research by the Joseph Rowntree Foundation in the UK.(Joseph Rowntree Foundation, 2001) has established the following basic guidelines which include;

External

- Parking space capable of enlargement to 3.6m
- Minimum distance from parking space to entrance
- Approach paths suitably wide and level or gently sloping
- Wheelchair accessible lift
- Covered and illuminated entrances without steps

Lower floor

- Wide front door and ample hallway widths
- Turning space for wheelchair in all ground-floor rooms (1500mm)
- Wheelchair accessible downstairs toilet/ shower provision
- Sitting room at entrance level
- Walls in bathrooms and toilets capable of taking handrails
- Bed space on ground floor in two storey houses

Upper floors

- Bath/ bedroom ceiling capable of supporting lifting hoist
- Provision of future stair lift and space for through floor lift
- Easy access bathroom layout

Features and Fittings
- Window sills no higher than 750mm, windows easy to open
- Switches, heater control etc, easy to reach

3.2 Smart Typologies.
The resurgence of modular construction can also be closely linked with current employment trends. The different materials and trades used in the construction appear to more closely resemble those of production and off-site working methods. The gradual decline in trades in the UK over the years in favour of IT, tourism and banking as reported in the recent Construction Industry Training Board report, 'Skills Foresight' has meant that the industry needs to recruit some 380,000 new trades-people in the next five years to prevent a manpower crisis. (CITB, 2002) This shortage of site based trades will inevitably be reflected in more expensive wages, and as it filters through the system the cost will obviously come out of the pockets of the would-be buyers. In the Yorkshire and Humberside region alone, it is estimated that the skill shortage reflects some 3,500 managers and 5,500 carpenters and joiners.

The question perhaps need to be asked then, with high unemployment such as that which is witnessed in Hull, why is there such a shortage of tradesmen and women? The construction industry already employs one in fourteen of Britain's working population, and to attract more would inevitably include the rise of salaries and benefits, which again would be reflected in housing prices at the expense of the would-be buyers. Such important issues are being raised as the council looks at new initiatives to improve and enhance its own housing stock.

The resurgence of modular housing, also includes the resurgence of methods of production as opposed to construction which may in some way invade or support it, as was seen during the post-war housing crisis? Kingston-upon-Hull's declining industry culture, in this way would be seen to receiving a boost from the newer pioneering industries of its communications counterpart. Hull has major business links with such industries as shipbuilding, caravans and other mobile buildings which could provide opportunities if fully utilized towards new housing types. The effect of this could be seen geographically, as new typologies grow from declining regional industries, creating modern hybrids resulting in economic injections into such important economic areas. The consequences of such economic strategies would hopefully create a more regionally inspired, affordable housing, stamped with the identity of Hull resulting in the rise in the economic boost that Hull, like many others in the north of England requires so badly. The creation of these 'new' typologies, together with the new technologies, could see the city center as a bright social area once more, with the inclusion of a densely populated heartland.

4. SMART COMPONENTS AND MATERIALS
Monsantos house for the future, developed in the 1950's embraced the new plastic materials, and was thought to be the future of housing with such innovations including insulated glass walls, picture telephones, plastic chairs, microwave ovens, speaker phones and electric toothbrushes. (website, 2002) The reasons such schemes, along with the many failed post-war modular housing attempts, were not realized, is that houses are not just the expression of technology and culture, they are an expression of the people who reside within them. The

change in lifestyle in the latter half of the last century, has far surpassed that in the previous half. The psychological attachment that we now have, in regard towards the house and its associated materials is far more open than any reserved attitudes in the fifties. The need for environmental products has seen the use of recycled materials, in effect waste, being used extensively. New environmental appraoches have broken boundaries that many had in accepting the new or different when delivered under this green banner.

4.1 Material Psychology

This has made possible the use of such materials as cardboard, paper products, and more extensive use of its parent, timber. All of which have a low environmental energy and are recycleable. The resurgence of the low-tech solutions makes for an interesting solution to the high-tech lifestyle that is being investigated in Kingston upon Hull. The way we live is increasingly being surrounded and held in place by technology and this does not appear to relate to the physical structure of our habitats. As fast as technology is pushing its boundaries in one diection, sustainability is diversifying the use of materials and the boundaries of their aplications in the other. Increasing use is being made from other low embodied energy materials in addition to waste card, such as straw bales and earth rammed wall structures, materials that would normally be attached to pioneering buildings, but are fast becomming realised as main stream possibilities.

5. CONCLUSION

Hull's unique technological position as we embark on this next century is the ideal platform for the reincarnation of a city creating a new digital urban fabric. The new housing that is required, if informed by this and the regions existing industry sector could form an economic and sustainable catalyst for more innovative housing typologies including the new live/work digital clusters, and low tech innovative use of materials. The more unreservedly we view materials and associative processes, the more we could open new paths for interesting hybrids of high and low tech solutions to Hull technological reincarnation. The question remains is that if all these opportunities are seized, what will the urban fabric, and Hull as a community look like in ten years time?

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Zinc and Steel - Partners in sustainable Construction

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1. INTRODUCTION

1.1 Sustainable construction and its implications for materials selection

The recent increasing focus of governments, industry and public on the objectives of sustainable development has not escaped the attention of architects, designers and manufacturers. Nor has this interest escaped the commercial competitiveness between various construction materials, especially those attempting to promote the "environmentally friendliness" of their own products. The goal of identifying sustainable construction practices and strategies for improving the sustainability of construction has emerged, is growing and has a potential for powerful environmental and commercial impacts.

Industries supplying products and services to construction (and other markets) are responding to the sustainable development challenge through appraisal of production processes, business practices and social performance. A pro-active approach to addressing these issues, together with assessments of product contributions to advances in sustainable construction, is becoming prerequisite for materials supplied to construction markets.

2. ZINC AND SUSTAINABLE DEVELOPMENT

2.1 The Zinc industry's commitment to Sustainable Development

The International Zinc Association recently adopted a Sustainability Charter to provide guidance for the industry's response to sustainability challenges. From this foundation, a Sustainability Strategy has been developed and can be summarised as follows:

- Assessment of future trends and development of zinc sustainability indicators
- Develop and communicate a full understanding of zinc's environmental impact and its essential contribution to human health and eco-systems
- Ensure efficient resource use for zinc production and recycling
- Reduce energy intensity of all processes within the value chain
- Control zinc emissions (from point and diffuse sources) to appropriate levels
- Manage production to appropriate worldwide social and environmental standards
- Develop an integrated product policy for zinc's life cycle

In 2001, IZA appointed an independent consultant, Ove Arup & Partners International, to develop a preliminary sustainability assessment of the industry and its strategy. It was intended to deliver a new strategic framework and support the industry's management of sustainability issues.

The appraisal identified those sustainability issues of relevance to the zinc industry and its markets – including, the use of steel in construction. The outcomes of the SPeAR™ (Sustainable Project Appraisal Routine) assessment for zinc are illustrated graphically in chart for zinc (Figure 1). The chart will help to identify key areas for further industry attention and future revisions to the appraisal and the chart will help to monitor progress.

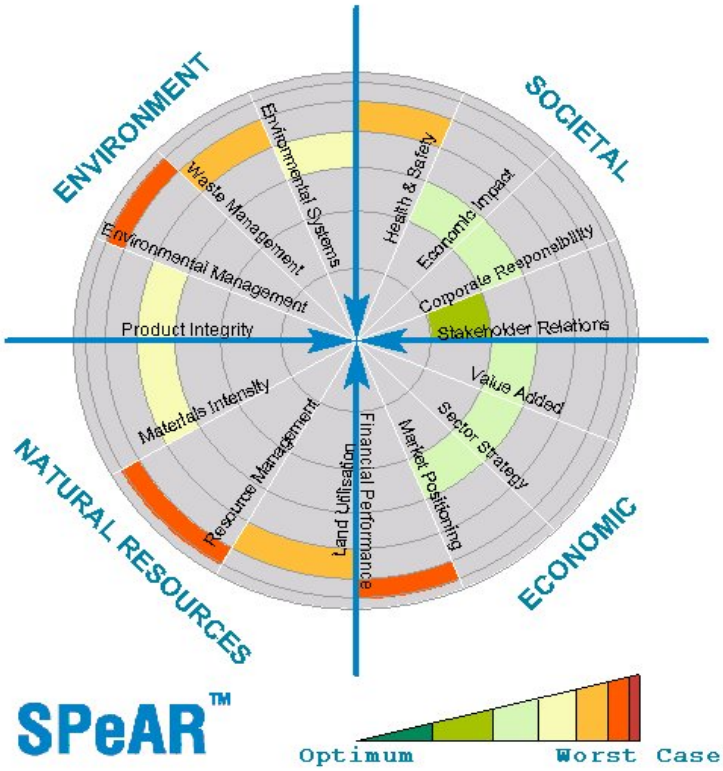

Figure 1 SPeAR™ Chart for zinc – a tool for setting a strategic framework and charting progress in tackling sustainability (Ove Arup & Partners International, 2002)

2.2 Consulting zinc's customers – setting our priorities

IZA has begun the process of customer consultations on sustainable development, an initiative intended to present and test IZA's present strategy and appraisal with zinc's user industries and markets. This process is not complete, but early results confirm the following three priorities:

- **Durability:** Zinc plays a vital role in expanding use of steel through enhancing its durability. Up-to-date information and advice on zinc's protective properties must be readily available.
- **Recycling:** Zinc is inherently recyclable. However, there is a need to remove technical, regulatory and market barriers to recovery and recycling of zinc-containing steel production dusts.
- **Environment:** There is a need to effectively communicate on zinc's environmental impact.

3. DURABILITY

3.1 Corrosion performance of zinc

Zinc's resistance to corrosion depends primarily on a protective film formed on its surface. For atmospheric corrosion, atmospheric contaminants affect the nature and durability of this film. The most important contaminant affecting zinc is sulphur dioxide (SO_2) and it is the presence of SO_2 which largely controls zinc's atmospheric corrosion rate.

It is widely documented that atmospheric SO_2 levels have fallen significantly in most Organization for Economic Cooperation and Development (OECD) countries over the past decades. However, the majority of corrosion performance data were developed during the period 1950-1970. Many standards and guidance documents are still based on this information that, unfortunately, is no longer valid. This can create a situation of conservatism for the specifiers of protective zinc coatings, for the newer zinc and zinc-alloy coatings for steel today will give far better performances than indicated from outdated data.

Figure 2 very clearly illustrates the link between zinc durability and atmospheric SO_2 levels.

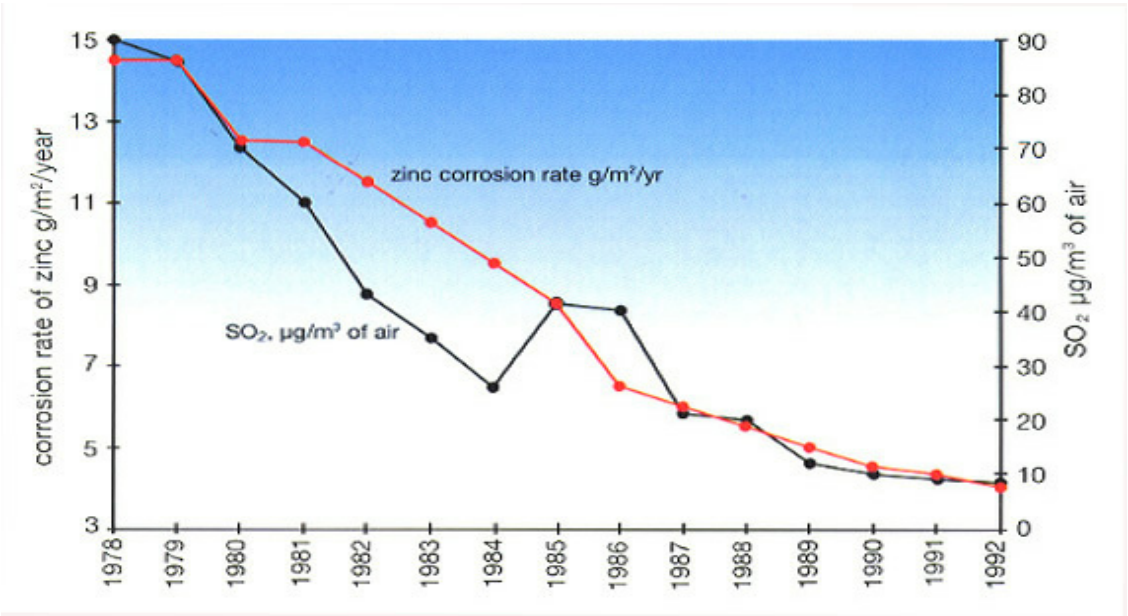

Figure 2 Reduction in sulphur dioxide levels in Stockholm, Sweden during the period 1978-92 and accompanying decrease in the atmospheric corrosion rate of zinc.

This downward trend and consequent improvements in zinc performance will significantly enhance the contribution of zinc-coated steel to sustainable development by providing, at no additional cost, more durable structures for shelter, infrastructure, transportation and many other applications. This can be very important for the current, worldwide steel industry market development activities directed to continuously coated steel sheet for use as light-gauge residential framing, steel roofing, and steel and steel panel facades. Each product and market has its own conditions and drivers, for example:

- Light gauge steel is both an economical and environmentally friendly choice for single and low-rise residential framing. However, with the support of negative marketing efforts by competitive materials, some homeowners and contractors have been concerned about corrosion limiting the life of relatively thin, cold-formed framing members. The truth is that steel framing has an indefinite life - provided it is not exposed to water by penetration of the

exterior building envelope. IZA has taken on the responsibility of both researching this issue and publishing the resulting information. In addition, IZA is currently developing, for free distribution in quantity to the steel industry and its related residential framing trade associations, a lecture and publication package on the corrosion situation for steel framing. A companion package for steel roofing is under development for release in 2003.

- Steel roofing, coated with zinc or zinc alloys and usually left bare, has become the standard for low-slope industrial and commercial roofing. Its life-cycle costs are far superior to built-up (tar and gravel) roofing. But the key environmental advantage of this product is that it adds so little weight to the roof system that it can be applied over existing roofing materials, thereby saving the cost and risk of removing environmentally negative products that, in older roofs, may contain asbestos.

- For residential applications, steel also is growing in popularity for a number of reasons:
    - The weight issue is the same as for commercial/industrial roofing. A new roof can be placed over an existing roof without removing the old roofing materials.
    - Steel roofing now is available in a wide range of colours, finishes and textures. It can be produced to look like wood shakes, clay tile and slate – or anything between.
    - As product availability increases and installers become more efficient with a different product, costs of steel roofing have come down to the point where steel can be competitive at first cost. It always has had the best life-cycle cost advantage of typical roofing materials.

- For siding and facades, steel has long been the preferred choice for industrial applications. As new products are being developed with an architectural flair, steel now is being used as a new standard façade for commercial construction.

- In addition, for both facades and roofing, insulated steel panels are growing in use for a different set of reasons:
    - Construction is extremely rapid; for industrial applications the panel can be both the interior and exterior finished surface.
    - Energy savings can be very significant with insulated panels available in a wide range of thermal and fire resistant properties.

A similar list of applications exists for post-fabrication zinc-coated steels of all types:

- In growing evidence throughout the world, “street furniture” (benches, waste containers, pedestrian walkway barriers, etc.) formerly made of less-durable materials, is being replaced by steel protected with a coating of post-fabrication, hot-dipped zinc.

- Automobile parking structures, particularly those left open to the weather for reasons of fire brigade access, have had a record of high costs for maintenance painting – both for the nuisance of painting and the loss of revenue during painting. Total galvanizing of the entire steel framing is now becoming more common as a solution to this situation.

- For those areas where electrical power is distributed by overhead lines, the wooden pole is becoming an environmental and sustainable problem for two reasons – end-of-life disposal and leaching of toxic preservation chemicals into soil. Steel poles, protected with a coating of zinc, are becoming the preferred choice for a number of reasons:

- At end-of-life, they are 100% recyclable.
- There are no toxic discharges of preservatives into the soil.
- The steel pole is stronger than wood, better able to accommodate adverse loadings, has a longer life span than wood and requires less frequent replacement with the associated infrastructure and environmental impacts.

Note that in each of the above mentioned market segments, the common denominator is steel coated with zinc or a zinc alloy. None of the above applications would be possible or even acceptable without the relatively permanent mitigation of corrosion. Paint can serve a supplementary barrier and finish function, but paint on bare steel is temporary at best. Paint on zinc-coated steel is long-lived, aesthetic, practical and economic.

3.2 New developments

For designers and specifiers to take advantage of this opportunity, there is a need for current information on zinc's corrosion performance. Corrosion mapping has been performed in recent years, specifically within the UK, Mexico, South Africa and Australia. The "Zinc Millennium Map", covering 1998-2000, can be accessed interactive format at www.galvanizing.org.uk.

Another important development is the forthcoming launch of a "Zinc Coating Life Predictor" developed by the International Lead Zinc Research Organization (ILZRO) in cooperation with the zinc industry. Care has been taken to use current information and, in testing, it has proved remarkably reliable. Soon to be made public at www.zincworld.org, this tool will permit predictions of zinc coating performance based on input from a range of variables including SO_2 concentrations, rainfall, temperature, etc.

4. RECYCLING

4.1 Recyclability and current status of zinc recycling

Zinc is an inherently recyclable non-ferrous metal and can be recycled indefinitely without any loss of physical or chemical properties. This presents a major opportunity to build a sustainable future for zinc-coated steels.

At present, approximately 70% of zinc comes from mined zinc ores and about 30% comes from recycled, or secondary, zinc (representing 80% of the zinc available for recycling). The recycling level continues to increase, from both progress in zinc production technology's adaptation of secondary material and in zinc recycling technology itself.

4.2 Advancing the recycling of zinc-coated steels

The long and increasing life of zinc coated steel products in construction makes forecast of their emergence in waste streams difficult to model. However, it is certain that the increased use of zinc for corrosion protection will result in more opportunities to recover zinc through the scrap-charge Electric Arc Furnace process. In order for this to be successful, a number of technological and regulatory challenges will have to be met. The zinc industry is committed to meeting these challenges and has recently formed a task force to identify the criteria for significantly enhancing the recovery rates of zinc from zinc coated steel products.

5. ENVIRONMENT

5.1 Essentiality, natural occurrence and zinc deficiency

All living organisms need zinc – it is essential to life. The amount of zinc present in nature varies widely, so living organisms have natural processes that regulate their uptake. Deficiency occurs

when the amount of available zinc is insufficient to meet the needs of an organism. This occurs in the environment and in human nutrition (researchers have estimated that a staggering 49% of the world's population is at risk from zinc deficiency). Zinc deficiency in agricultural soils is common on all continents and leads to inefficiencies in crop and livestock production.

5.2 Risk assessment

It is important to identify whether the many applications of zinc could give rise to environmental concentrations that may do harm. Assessments of such risks are part of a European Union regulatory framework; the "Existing Substances Regulation", for which zinc is the first essential, natural metal to undergo the formal risk assessment process. Much has been learned:

- Most importantly, existing assessment methodologies (first developed for organic chemicals) do not work for zinc.
- In order to properly predict zinc's impact on ecosystems, there is a need to quantify the reduction in its bioavailability when it enters the environment. Total zinc is not an accurate measure of its impact.
- Up-to-date information must be used to predict the small amounts of zinc corrosion products washed from exterior, exposed zinc coated structures. Failure to do so results in significant overestimation of environmental concentrations.
- Recent work has shown that, even in areas of apparently high local zinc concentrations, no adverse effects are seen on the environment.

The bioavailability of zinc is currently being explored in detail through an extensive research programme. This research, to conclude in 2003, will deliver clear predictive models to quantify zinc bioavailability in waters, sediments and soils to further underline confidence in zinc.

6. CONCLUSIONS

The current focus on sustainability issues in materials selection and design choices for construction have very important and positive implications for the use of zinc coated steels. Significant opportunities exist to underline the contributions that zinc coated steels can make to sustainable development. There also are important challenges to exploiting these opportunities – in particular:

- to address issues relating to recycling zinc coated steels.
- to ensure that up-to-date corrosion performance data is used to maximise material performance.
- to accurately communicate the facts on zinc and environment to users and specifiers.

The zinc industry is serious about its sustainable development strategies. It is important to highlight the very real contribution that zinc coated steel products will make to the steels of a sustainable world. The essentiality and natural occurrence of zinc – and our improving understanding of its role in the environment – will prove a significant asset in building sustainable uses for zinc and zinc-coated steels.

Sustainable construction sites and project economy - A study of the entrepreneur's economical consequences of environmental activities on Norwegian construction sites.

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This paper is a preliminary report of the ongoing diploma work of MSc student Tora Langseth and her supervisor Lisbeth Stokke Fjeldly. The diploma will be finished in June 2002. At this stage a report of the pre-studies will be presented.

1 INTRODUCTION

"Business as usual is not a sustainable option"

This study aims to investigate the relationship between project economy and sustainable building on Norwegian construction sites. This report will describe the project managers' role and their influence on environmental decision making in the construction process. It is hoped that this study will contribute to the advancement of construction safety and environmental focus in the construction process.

1.1 Background

Economy is important for all companies and economic parameters are easy for all parts to comprehend. In the construction sector the economy of each project is one of the most important factors for success and failure. The challenge is that not all coherences are easily measured on an economical scale. One such example is the cost of waste disposal. It is easy to compare the delivery costs of sorted waste to that of unsorted waste. However, one kind of waste handling instead of another could lead to a more tidy construction site, in turn a tidier construction site might lead to a rise in productivity, reduced breakage, fewer accidents and reduced absences. The problem arises when trying to measure these possible benefits. It is difficult to estimate what amount of resources should be used on different environmental activities in a building project. Therefore NCC Norge AS has taken the initiative to carry out an economical analysis of relevant environmental activities on the construction sites.

1.2 Boundaries

The boundary of this study is limited to within the fence around the construction site, both in time and space. This means that economic analyses concerning the surrounding community are left out. Such considerations will be regarded only in the sense that certain environmental taxes and legislation will influence construction site operation. Hence the study will not take e.g. Life Cycle Assessment (LCA) into account. Nor are demolition and rehabilitation included in this survey.

2 THE ENTREPRENEURS ROLE

In each phase of the development process environmental improvements are possible, from the production of materials to dealing with the wastes created during and after construction. Firms can include environmental considerations in site preparation and the planning phases of new projects. Builders can work with clients to influence the owners in choosing high-performance structures that maximize available material and energy efficiencies. By improving operational efficiency of buildings and plants, it is possible to minimize waste and pollution. Since all contributors in the construction sector influence the process differently, it follows that they also have different responsibilities with respect to environmental work.

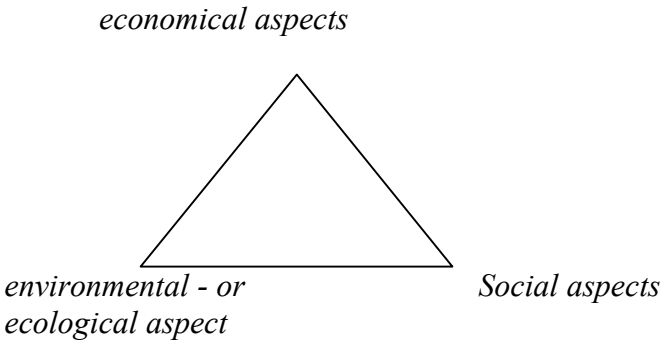

Figure 1 The companies' responsibilities

The entrepreneur's responsibility lies mainly in the construction phase. It is often the builder, along with his advisers, who is in charge of setting the environmental demands for the whole process. The builder is usually more concerned with the environmental state of the final project, and not so much in the ongoing work before take-over. However, some decisions on how to run the construction site can directly influence the use of the completed building. This is for example the case with the "Clean-building" process, which can contribute to a healthier indoor climate.

Though the entrepreneur is often familiar with the best environmental practice within the boundaries of available technology, even an environmentally conscious customer may not be aware of the possibilities. The new trend with more design and construct contracts, new types of tender and early cooperation with the builder gives the contractor better opportunities to influence environmental work in the early phases. After all, the mutual goal is, or should be, to get the highest environmental value for money.

3 SUSTAINABLE CONSTRUCTION SITES

For companies in the construction sector, the most important environmental aspects are:

- Efficient use of resources (LCA, waste management)
- Energy consumption (at the plants, but more importantly the chosen solution for the completed building)
- Emission and effluent control (air- and waterborne pollutants)
- Risk of damage to people's health caused by the state of the environment

Because of the project managers' traditionally limited influence on the latter three aspects, this study concentrates on use of resources. The most relevant environmental aspects for project managers are therefore waste management, the "clean-building"-concept and safety. All of these aspects can be carried out to different degrees. The aim is to find the point where resources are used most efficiently when considering all aspects of project economy.

3.1 Waste management and disposal

There are three ways in which a project can dispose of its waste. Due to large fees on unsorted waste, fewer and fewer construction firms choose to deliver all their waste directly to a landfill. The remaining options are source separation of waste, or sorting at a central sorting plant. Source separation is carried out to ensure better treatment of the waste produced.

This study will not include actions for reducing or eliminating waste at the source. This is because waste minimization is the responsibility of project planners, and something that project managers only control to a lesser degree.

3.2 ”Clean-building” concept

The ”Clean-building” concept includes finding good solutions for storing building materials at the construction site, tidying as well as continual and final cleaning. The concept also includes preventing dust both indoors and outdoors. The builder will often demand documentation on cleaning, indoor climate, ventilation and emission control. This concept started as a method to achieve a better indoor climate, but it seems to affect the quality of the whole building process. As a result more and more contractors choose to use the “Clean-building” concept in all of their projects. The “clean-building” concept can be carried out to different extents based on the builders’ and/or the contractors’ wishes.

3.3 Safety

In this study workers are regarded as a vital resource for the project. Prevention of accidents and reduction of risk of damage to people’s health will be measured in terms of project economy. This can for example be done by comparing the cost of preventive safety actions against the probability of a stop in production due to an occupational accident. In most cases the cost of occupational accidents has been estimated from the point of view of society as a whole. These costs can be free medical treatment, or the “value” of suffering from accidents. Such topics are not included in this report.

4 MEASURING THE ENVIRONMENT

All contributors in the construction sector should aim to find the optimal level of environmental solutions with a minimum use of resources. To make a useful evaluation of the different considerations, standardized numbers for environmental quality are needed. The task of finding these numbers has just started, but it is hard to find indexes that are clear and easily understood. Many environmental areas are either not yet well understood or are not amenable to factual analysis. But choices must be made, frequently requiring difficult value judgments and often with inadequate information.

4.1 Prices and values

For some objects there exist no prices for the obvious reason that the object is not traded in any market. That applies to human life and limbs, to the purity of air and water etc. Different stakeholders will look at these values in different ways. Economic considerations can be carried out in at least three different ways. First of all project managers will always ask themselves what is economically efficient for the project. Secondly, some activities will be beneficial for the company, but not necessarily for that single project. Prevention of moisture can be an example of this. Finally, some activities will be beneficial for society, but not for the company. An example of the latter may be extra measures to secure a healthy indoor climate in a school. In this study focus is kept on the construction industry managers and decision makers, and their point of view.

4.2 Short and long term consequences

Some of the detrimental effects of unwanted events are irreversible and some are of a long lasting nature. Relevant examples are loss of life and limbs, company reputation and environmental pollution. Should such effects far into the future, or everlasting, be accounted for in our economic analysis? If yes, how should distant effect be evaluated? It can be hard to motivate the project managers to spend the extra resources if they do not immediately see that there also are economical gains in the short run. One solution can be to connect the costs of defaults and defects to the warranty period and further use.

It is stressed that economic aspects will be measured separately for each project. However, it is easier to do a task the third or the forth time as new routines become more familiar. Is it then fair to put all the costs of for example a safety course solely on the first project after the course was finished, or should one, in this case, divide the sum on more than one project?

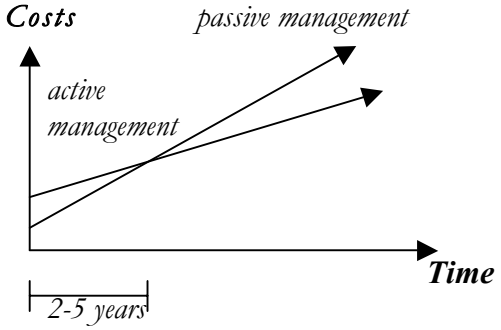

Figure 2 *Economy in short and long run.*

4.3 Workers' efficiency

The workers are one of the most important resources in a construction company. In Norway this is especially true because salaries amount to such a great part of the company's expenses. This should lead to the conclusion that even small increases in efficiency would entail considerable alterations in the project's economy. Assuming that a tidier construction site leads to more efficient builders, then this "gain" in salary expenses can be used to compare the cost of the extra hours which were used on planning and administrating "Clean-building". How does one know that efficiency has increased? After all no two construction sites are alike. A construction site changes constantly and seldom looks the same two hours in a row. Is it possible to find links between construction sites with "Clean building", good bonuses, few delays, and little overtime?

4.4 Occupational accidents

We have to put a price on the cost of accident prevention and the cost accidents cause. These numbers can be the cost of planning and arranging safety courses for the workers, compared to work laid down to find new craftsmen when employees become indisposed after an accident. It may seem cynical to do so, but it is hoped that this will be recognized as an acceptable way of transforming objects of a non-economic nature into monetary terms.

5 FURTHER WORK

Can demands for increased profitability be combined with demands for an improved environmental profile? Bjerkan (2001) in Veidekke shows how statistics for accidents over the last ten years have been *omvendt proportional* with increased profitability. This may

indicate a connection, however no one can prove this. To prove the connection one would have to look beyond traditional ways of setting costs. All values that are normally not priced would have to be taken into account, because they all influence the work done in different ways. However, one can not only take into account the unseen values that contribute in a positive way, but must also include values that have a negative effect on profitability.

Previous examples have been given of such unseen positive values as improved efficiency/productivity, fewer injuries and better use of resources. An example of unseen costs could be the reuse of old windows in a building project. Seen from a project economy point of view you would have to take into account the value of a new window fully installed, then subtract the expenses for storage and quality control, reduced insulating properties and shorter lifetime of the old window. From this point of view it can be difficult to defend reuse of a window. However, taking several possible bonuses such as increased goodwill, public relations and better use of the society's resources, reuse of a window cannot easily be turned down.

Up to this point it has been argued that money can be made from environmental activities also when seen from a project's economic situation. Further work will aim to prove this connection. An attempt will be made to study and compile data from previous studies as well as from new case studies of NCC's own building projects. Preliminary investigations indicate there is no clear method to measure profits from different environmental activities. One way to solve this can be to compare data and values with a known or fictive average or with a worst case scenario.

5.1 Case description

The study will include a case study of six average sized projects where NCC was the totalentreprenør. Environmental management of large prestigious projects has not been included because focus is put on what project management can do in their day-to-day work, and not only what is possible with an active builder in charge of setting demands. The chosen projects are about the same size in value, but they are situated in different Norwegian locations. It is a problem within the construction industry that not two projects are the same. In an attempt to limit the differences, three of the chosen projects have the same builder. The case study will be carried out in May 2002.

6 CONCLUSIONS

Better environmental performances are moving up on the agendas of corporate executives as fines and penalties increase and liability laws stiffen. Some companies are finding ways to turn environmental improvements into cost savings and profits. It is often said, especially in public speeches that "environmental activities represent value for money". However, the longer time spent without proving this, the less believable it becomes.

Some will claim that the contractor has a moral responsibility to always choose the more environmentally friendly solution. As far as traditional contracts are concerned, we believe the contractors main task is to find the most economically beneficial ways to conform with environmental legislation and customers' demands. In other words, value for money. However, in new tenders forms like design and construct contracts, the contractor should take on an active role and present sustainable solutions both in the building process itself and for the future use of the building.

Regardless of the contract form one needs to be able to measure the effect of the different environmental activities. In this study we have argued for the connection between costs and benefits of each environmental activity seen from a project economy point of view. To prove these connections an attempt will be made to study and compile data from previous studies as well as from new case studies of NCC's own building projects. The results from these studies will be presented at the SB 02 conference in September 2002.

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Harmonization of LEED and BREEAM Green Leaf

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INTRODUCTION

With the development of BREEAM Canada, BEPAC, GBTool, BREEAM Green Leaf and, most recently Green Globes and a Canadian version of LEED, Canada has been a fertile ground for rating-system development activity - with one system building on or evolving from another.

Several interrelated concerns and events led to a project to harmonize two of the most promising systems in Canada – BREEAM Green Leaf and LEED. First, the federal government and other stakeholders had been exploring the potential to develop an assessment system that would combine the best features of existing tools and frameworks. The Royal Architectural Institute of Canada's Sustainable Building Canada Committee (SBCC) also wished to recommend an assessment system for use in Canada. Finally, both LEED and BREEAM Green Leaf had strong supporters. LEED Canada was being adapted for the British Columbia Building Corporation and the City of Vancouver, while BREEAM Canada and BREEAM Green Leaf were already being used by various organizations including the federal government and the Canadian Federation of Canadian Municipalities.

The harmonization project was undertaken by the Athena Sustainable Materials Institute in association with the University of British Columbia and ECD Energy and Environment Canada Ltd.. Funding was provided by Enbridge Consumers Gas, Natural Resources Canada and the Canada Mortgage and Housing Corporation. Because the harmonization study and the LEED Canada Adaptation Study were done concurrently, harmonization was limited to the present US version of LEED 2.0. Because LEED 2.0 is not particularly well suited to the assessment of existing buildings and LEED for existing buildings is only in its pilot stage, the harmonization study was limited to new buildings (i.e. buildings at the design stage).

This paper will provide an overview of the harmonization study. A description of similarities and differences between BREEAM Green Leaf and LEED will serve to show how the two systems, now harmonized, will complement each other by meeting diverse needs of the building community. Finally, it will present arguments for multiple assessment systems in the marketplace.

OVERVIEW OF THE HARMONIZATION STUDY

The objective of the study was to analyze the BREEAM Green Leaf and LEED systems to identify areas where Green Leaf could be modified to harmonize with LEED. Since LEED 3.0 is not likely to be released before 2005, rather than combining elements of the two tools, harmonization was defined as adapting BREEAM Green Leaf so that the overall goals and

performance requirements between BREEAM Green Leaf and LEED are identical, and providing equivalencies between the ratings.

The harmonization of BREEAM Green Leaf and LEED was theoretically simple, because LEED uses the original structure of BREEAM (i.e. intents, requirements, general background, technologies and strategies that might be helpful to meet the requirements.)

Another fundamental similarity between the two systems is that BREEAM Green Leaf makes reference, as does LEED, to a number of standards rather than directly including benchmarks within the criteria descriptions, thereby offering the advantage of staying current without having to update the specific wording of the credit requirements.

Where the two systems differ chiefly is that BREEAM Green Leaf addresses some issues that are not covered in LEED and follows a different sequence based on project delivery stages. BREEAM Green Leaf also addresses situations where certain criteria may not apply. This is fundamental in that it allows trade-offs during the design process. In addition, the verification of specific credits is broken down in BREEAM Green Leaf into line items of detailed questions and answers.

BREEAM Green Leaf is also positioned as an eco-rating system and not as a certification system. It was conceived as a part of a suite of assessment tools that meets the various needs of the marketplace but have a common basis, and can build on each other as well as "talk to one another". Thus for example, BREEAM Green Leaf can serve as an entry-level system for LEED certification.

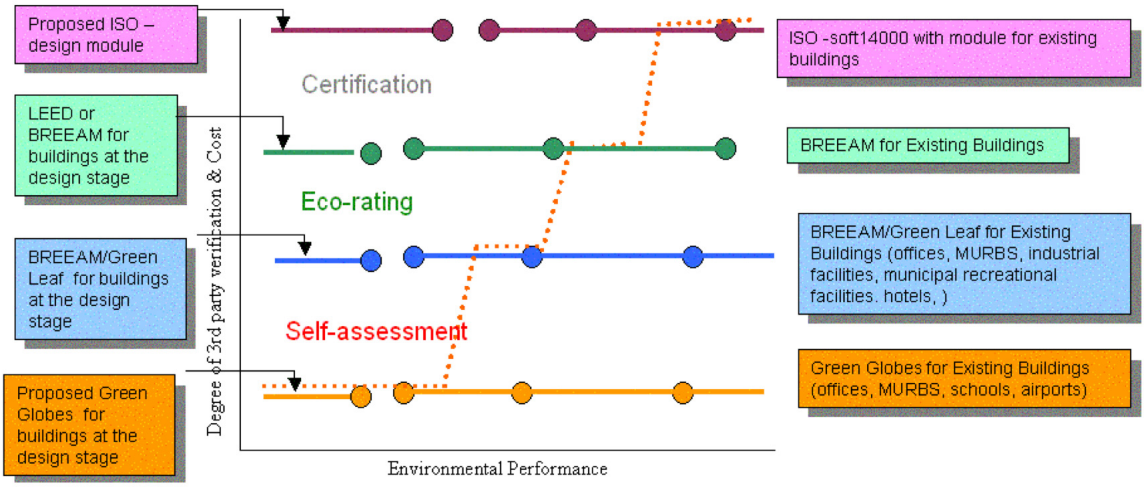

Figure 1: Suite of assessment tools that meets the various needs of the marketplace.

Because of these differences, the basic approach was to compare and harmonize the intents and substantiation of individual credits, rather than to fully harmonize each and every BREEAM Green Leaf requirement. A demonstration of the similarity of the intents set out in the two methods was critical because intents express the fundamental environmental performance expectations and speak directly to the goal of market transformation. The study therefore involved matching the individual BREEAM Green Leaf intents to corresponding LEED intents and ensuring that the criteria used in each system are capable of meeting the intents' goals. Since there was agreement that both methodologies can achieve and

meaningfully ensure the implementation of the same objectives, the credits were deemed harmonized.

The real demonstration of feasibility, however, is in the implicit weighting of the environmental issues. Neither LEED nor BREEAM Green Leaf use explicit weightings, in contrast to GBTool, for example, but they do have implicit weighting, based on the number of credits and points assigned to each performance category. If the implicit weightings were different, the feasibility of harmonization would have been in question. But as Table 1 demonstrates, the implicit weightings are very similar in the two systems.

Table 1 below shows the percentage of points assigned to each of the five LEED performance categories by the two systems. The percentages were developed by appropriately reassigning those BREEAM Green Leaf credits from categories that do not exist in LEED, but omitting any BREEAM Green Leaf credits that are not covered at all in LEED. While the percentages of points assigned to specific categories vary somewhat, the relative importance, as shown by the rankings of the categories based on the point assignments are identical.

Table 1 Percentage of points assigned to each of the five LEED categories

LEED	**Points**	**% of total points**		**BREEAM Green Leaf**	**Points**	**% of tota points**
Energy and Atmosphere	17	25		Energy	325	33
Indoor Environmental Quality	15	22		Indoor Environment	220	22
Sustainable Sites	14	20		Site	220	22
Materials and Resources	13	19		Resources	100	10
Water Efficiency	5	7		Water	85	9
Innovation/Design Process	5	7		Project Management	50	5
Total	69	100%			1000	100%

Because BREEAM Green Leaf is applied in a spreadsheet, LEED values can be readily assigned to BREEAM Green Leaf criteria, thereby generating approximate LEED equivalencies. For example, both systems have three criteria related to public transportation, with similar intents and requirements. However, BREEAM Green Leaf awards more points for close access to public transportation than for access to alternative refuelling, whereas LEED awards equal points for all three criteria. Using the spreadsheet capabilities, it is possible for a user to determine how many points are achieved using either scale. BREEAM Green Leaf thus provides an equivalent LEED rating and gives the user both a Green Leaf and approximate LEED compliant rating if so desired, without compromising its point system. This dual rating capability is provided with due regard for the LEED prerequisites, by indicating to the user if any prerequisites are not met. Once LEED-Canada becomes accepted and adopted, some adjustments may be necessary in BREEAM Green Leaf to ensure consistency in the requirements, standards and references.

HOW BREEAM GREEN LEAF AND LEED COMPLEMENT EACH OTHER

No one tool or system can be expected to meet the full range of design assistance and rating needs of the building community. Since building certification is only one, and perhaps not the most important, of the many values and benefits of either LEED or BREEAM Green Leaf, the ultimate system is likely to be a harmonized set of tools, with horizontal integration to meet the needs of various building types and functions, and vertical integration to meet the needs of different client groups with different budgets, knowledge, and interest levels. The ultimate underlying goal in harmonizing the two systems has been to position BREEAM Green Leaf as

an entry-level system that can advance market transformation by informing the building design process. Also it is anticipated that BREEAM Green Leaf will continue to serve as a less expensive and perhaps more suitable design methodology. Where the two systems will continue to differ is in the assessment methodology, the degree of substantiation for certain items, and program delivery.

An important difference in approach is that whereas LEED criteria address the multitude of stages in no particular order, the BREEAM Green Leaf methodology is sequenced, and follows the design stages of the project delivery process, using questionnaires and guides to guide the project team in:

- Design objectives
- Site analysis
- Programming requirements
- Schematic design
- Design development
- Construction documentation
- Construction
- Commissioning

The protocol is seamlessly extended to evaluate the energy and environmental performance of existing buildings at the in-use stage, thereby forming a continuum throughout the building life cycle. While the protocol is designed to be used by the design team at all stages, the actual quantifiable assessment for the design occurs only at two stages:

- *The preliminary assessment* at the *Concept Design* stage reflects the degree of environmental performance that the client desires for the project. The assessment also provides an opportunity to impart to the design team environmental design advice, if so desired.
- *The final assessment* at the *Construction Documents and Specification* stage (*Performance Specification* stage in the case of design built projects) provides a benchmark of the environmental performance. It also provides a benchmark to evaluate construction tenders. In the case of design-build, it indicates how closely the Design-Builder's bid comes to meeting the client's environmental requirements.

BREEAM Green Leaf promotes an integrated approach to the design process – especially in the early stages of design. This is very important, given that 90% of the design decisions are made in the first 10% of the design process. While LEED can inform the design process, and is used in that way, BREEAM Green Leaf puts greater emphasis on the stages of integrated design early to avoid the typical situation where design teams jump on the “green” bandwagon late in the design process, long after the majority of conceptual and site decisions have been made. Making meaningful changes this late in the process is always costly and in some cases impossible. Green Leaf is designed with the view that the decisions made early in the pre-design stage will impact the building’s performance throughout its life cycle, including the in-use phase. Thus it can help prevent the situation where design teams adopt a “green ” philosophy or objective too late in the design process to influence critical site development, envelope, and building system choices.

The chart shows where in the process-continuum the respective LEED and BREEAM Green Leaf criteria are addressed. It demonstrates how Green Leaf addresses most of the issues at all stages, including the pre-design, programming and concept design stages. Because of the specific way in which BREEAM Green Leaf is structured, it is conceivable that integrating Green Leaf in the early stages of the process may guide designers and improve the LEED

rating later on. It may also be somewhat easier to use during the design process because of its structure and the fact it is in a spreadsheet form.

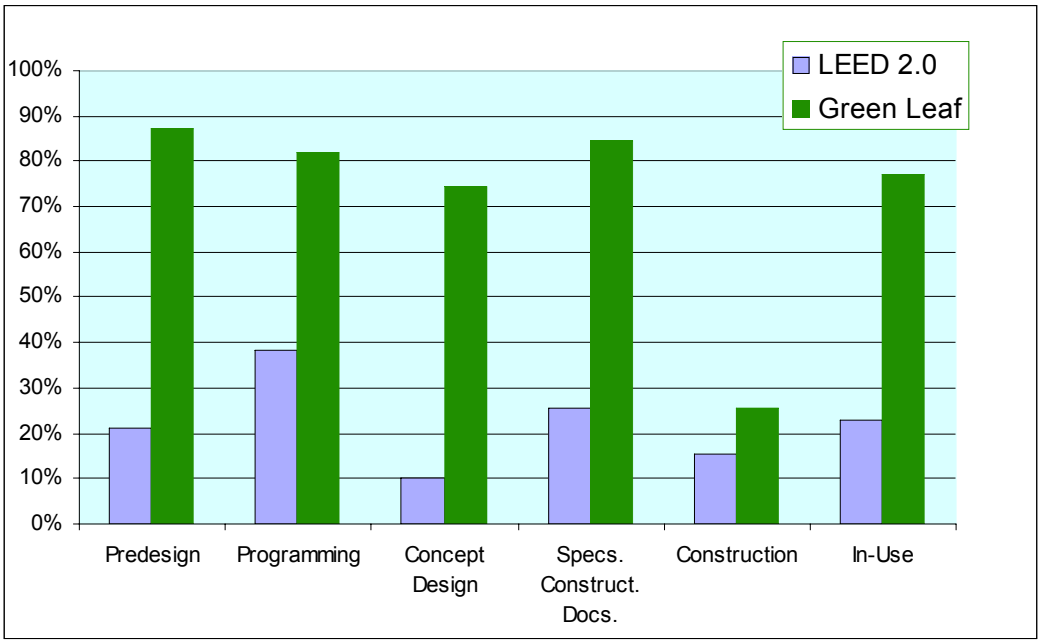

Figure 2: Comparison showing the percentage of issues that are addressed at various stages of the design process for LEED 2.0 and BREEAM Green Leaf.

Some proponents of LEED have argued that the professions, particularly engineers and architects, do not readily cope with more than one system, and that LEED is the logical choice given the desire for more cross-border activities. However, as systems build on or evolve from one another, there is no reason to assume that the process has ended, nor is there any sound reason that is should end. LEED itself has roots in BREEAM and BEPAC, and might not exist had they not existed first. The scope for change and improvement is greatly expanded if there is not only room, but also a welcome, for the fresh insights and approaches that new entrants so often bring to any field. That potential should not be stifled by holding up any one system as the final and only answer. Although the current momentum of LEED suggests it could replace other assessment systems, it may be that it will eventually spawn new systems by raising environmental consciousness. Furthermore, LEED is still new and relatively untested. While LEED was kicked off with considerable momentum, the current U.S. construction slowdown makes is hard to estimate the program's success. Organizations may develop derivatives or entirely new approaches tailored to their specific needs. In some case this may happen because their needs are beyond the scope of a formally approved LEED adaptation, while in other cases it may simply be easier to start with a fresh page, borrowing from LEED and elsewhere. It is simply too early to tell how the story will unfold.

Moreover, BREEAM Canada exists as a CSA standard, BREEAM Green Leaf is in use by departments of the federal government and others, and the most recent entrant, Green Globes is also gaining support. These systems are unlikely to disappear with the adoption of LEED-Canada. There are also precedents to support the premise that the marketplace can support more than one system. LEED is not the sole occupant of the US market. The Minnesota Design Guide and the US Army 's Sustainable Project Rating Tool (SPiRiT)are examples, but not the only examples, of other systems in use in the United States. Some of these tools came

into being before the full development of LEED 2 and the subsequent build-up of marketing momentum in favour of LEED. Nevertheless, the existence of these tools does not seem to have created undue market confusion, nor does it seem to prevent professionals from serving clients in Minnesota or from bidding on Army contracts. The existence of more than one system is a reality in both the US and Canada, and in the long run the cause of market transformation may benefit far more than it is hurt by the continued development and use of different systems. Indeed, it may turn out that, as in the case of BREEAM Green Leaf and LEED, the different systems are more complementary than competitive.

CONCLUSION

Many stakeholders in Canada have supported the notion of a hybrid that integrates the best features of all the systems. This may indeed be the right path, provided that the hybrid not be thought of as a single system or tool. It is better conceived as an integrated or harmonized set of tools: horizontally integrated to meet the needs of various building types and functions, and vertically integrated to meet the needs of different client groups with different budgets, knowledge and interest levels. Moreover, since at this stage of the design community's learning process, the vast majority of designers that are using LEED 2.0 are using it as a design guideline and are not going through the labelling process, this suggests that an entry level system may be appropriate. From that perspective, the complementary work can represent a significant forward step for those seeking market transformation in both Canada and the United States.

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Green Globes - An interactive online environmental performance assessment tool.

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INTRODUCTION

Since buildings consume 40% of the world's materials and energy and account for 17% of fresh water consumption, the need to improve their energy and environmental performance cannot be underestimated, yet the societal inertia in North America has resulted in a lagging response. One of the key measures to transform a market is the introduction of energy and environmental building ratings, because they provide a benchmark against which improvements can be measured. Despite of proliferation of assessment methodologies, the response from building owners and property managers has been lukewarm. Green Globes was developed to try to make a building rating system more attractive to users.

In 2001, the Canada Mortgage and Housing Corporation (CMHC) conducted *BREEAM/Green Leaf* pilot assessments of several multi-residential buildings. The purpose was to evaluate the performance of typical buildings. Feedback was obtained from the building owners and managers of the buildings on the value of the assessment process. Based on the findings of the pilot, was created an online methodology, called *Green Globes*, with the expectation that it could lead to greater acceptance in the marketplace. The method is the latest of the BREEAM/Green Leaf-based suite of eco-rating evaluation tools that have been used for over 700 buildings, both publicly and privately owned and managed, in Canada. This paper will provide an overview.

OVERVIEW

Designed for building owners and managers, Green Globes is an online auditing tool for evaluating energy and environmental building performance. The tool is based on a confidential questionnaire and generates an online report.

As mentioned above, Green Globes was developed following a pilot by CMHC of BREEAM/Green Leaf to obtain feedback from building owners and managers of multi-residential buildings on the value of a whole-building assessment. That study indicated that the greatest interest of users lay in:

- The comparative performance of the buildings
- hands-on, practical learning experience about environmental issues and possible improvements.
- indications of the potential operational savings and of where retrofit dollars might be best spent.

- having an asset management tool to develop executive and management goals, policy objectives, training and capital expenditures and for portfolio reviews.

In order to address all the relevant issues, the online tool had to ask the right questions - and provide a report that building owners and managers would find useful, with the following characteristics:

- Simplicity
- Provision of benchmarks, not only against best practices but also compared to other similar buildings
- Indication of bottom line operational savings
- Provision of training and awareness – just the right amount of information when it was needed
- Affordability

BASIS FOR THE ASSESSMENT

The selection of issues in the assessment was based on previous work[1]. The areas that are covered by the assessment include environmental management, energy and transportation, water, resources (waste management and site stewardship), pollution reduction (emissions, effluents, hazardous materials, Workers' Hazardous Materials Information System (WHMIS), and other due diligence issues), and indoor environment (IAQ, Lighting, comfort and noise).

The distribution of criteria (Fig.1) is based on the mean of the British BREEAM, the Harvard and EPA ratings for the various environmental issues. Although for the most part, the various systems put a similar emphasis, there are some areas of divergence. For example, the Harvard rating system puts a greater priority on due diligence issues, whereas the EPA rating system puts greater emphasis on indoor environment issues. Using the mean of these ratings resulted in a balance being struck, and a distribution that correlates well with the majority of whole-building assessments.

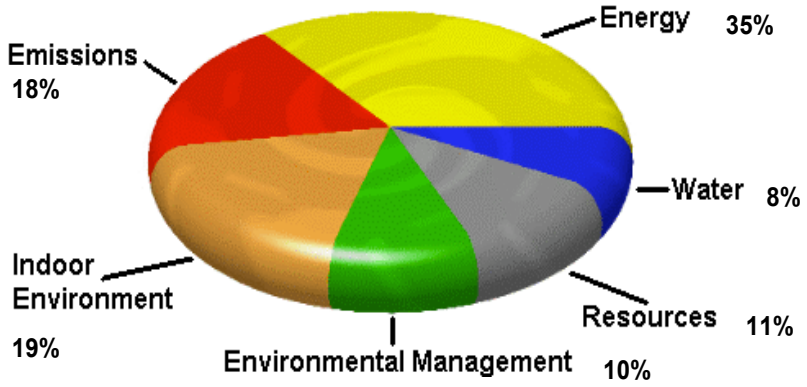

Figure 1 Distribution of assessment criteria

ASSESSMENT PROCEDURE

The online assessment process starts with online registration on the assessment website at http://www2.energyefficiency.org. Next is the selection of the building type – either office

[1] 1) BREEAM Canada, published by the Canadian Standards Association (CSA), 2) the Government of Canada's Public Works and Government Services Canada (PWGSC) *Progress Towards Sustainable Developments*, a BREEAM-based tool used for all federally owned buildings, and 3) the Green Leaf methodology which was developed for the Federation of Canadian Municipalities for their Municipal Building Retrofit Program

buildings or multi-residential buildings.

This takes the user directly to the interactive online questionnaire. Figure 2 shows the energy screen. There are approximately 150 questions with "pop-up" explanations. Other than data from energy and water bills, most questions require a simple "yes" or "no".

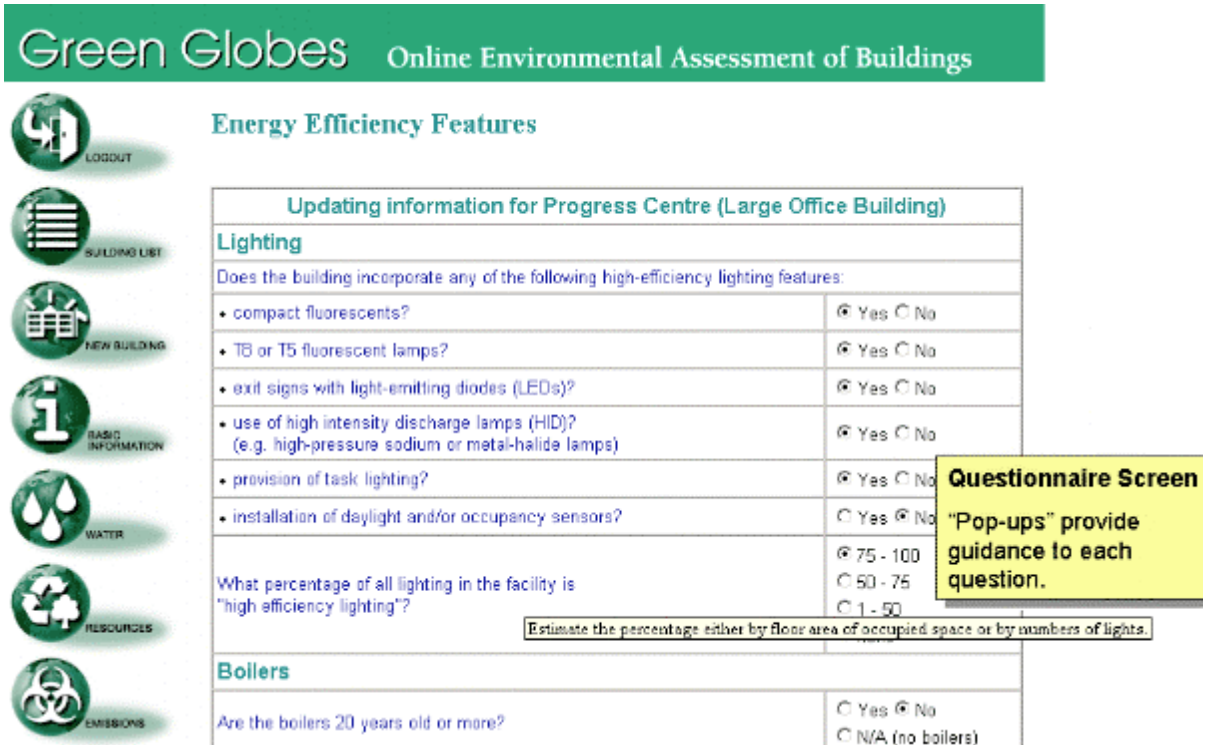

Figure 2 Data collection screen

To avoid the risk of "survey fatigue" associated with inputting data, efforts were made to keep the wording of the questions simple, and to provide brief explanations on how to answer the questions. The entire assessment can be completed in 2 to 3 hours. The questions are downloadable so that the assessor can walk around the building, jot down the answers and then fill-out the questionnaire online.

The data are maintained in absolute confidentiality, but are pooled anonymously together in order to generate quintile ratings. This makes it possible for owners/property managers to know how their building compares to others that have been assessed for each environmental issue.

Once the questionnaire has been completed, a report is immediately generated which can be updated at any time by changing the responses to the questions. This makes it easy to monitor continuous improvement.

THE REPORT

Achievement Highlights

The online assessment report provides the building scores in percentages, as shown in Figure 3. These scores represent building performance relative to best sustainable practice criteria. The report highlights the building's achievements in terms of the envelope and systems as well as management practices and gives values for energy consumption and equivalent CO_2 emissions.

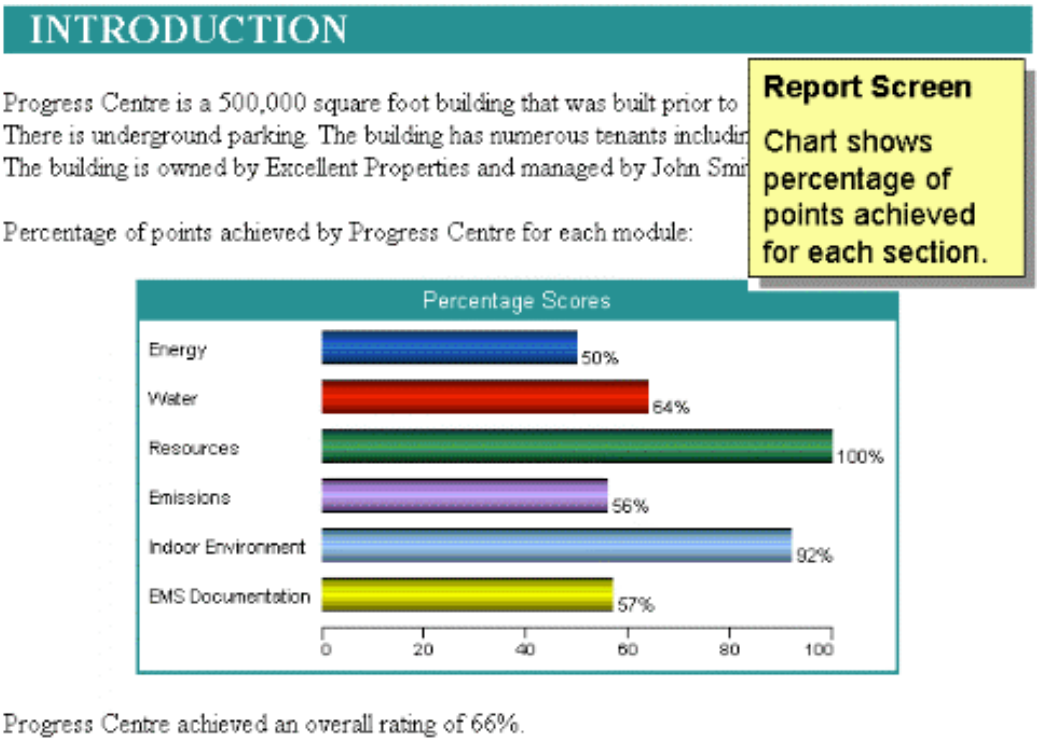

Figure 3. Sample report screen

Suggestions for Improvement and Potential Savings

Following the "Achievement Highlights", the report provides suggestions for improving the building's performance along with some detailed explanations and many hyperlinks to strategies and/or technologies with actual costs and paybacks. Since building operators see value in the assessment if it can provide recommendations to achieve operational savings, the software calculates the potential savings of the building with respect to energy and water. By linking the environment with the bottom line, it raises awareness that the majority of "green" practices for buildings are not only good for the environment but also contribute to improved efficiencies, operational savings, and tenant comfort and satisfaction.

For example, Public Works and Government Services Canada, using the precursor of the Green Globes, "*Progress Towards Sustainable Development Commitments*" increased its capacity to deliver building projects in an environmentally responsible manner. Use of the audit contributed to reduce energy consumption by 19% relative to 1990, thus saving the Canadian taxpayers $16 million annually in the 500 federally owned buildings. A $500,000 investment in office waste reduction in the National Capital Area resulted in an annual savings of $1million.

The Importance of Awareness and Training

The environmental assessment protocol is as much about raising awareness as it is about evaluating buildings. In recent years, there has been a proliferation of literature on healthy, green buildings. *The problem is not the lack of information, but finding the means to package it in a way that will make it easy for facilities managers to understand and implement what they have learned.* As shown in Figure 4, the assessment can be an excellent vehicle for presenting or recommending to property managers the wealth of useful information that has been compiled by organizations such as CMHC in a format that is easily applied on the job. Links also include online courses and product information. Linking recommendations to

information resources harnesses the power of the Internet, and provides hands-on education that is tailored to specific needs.

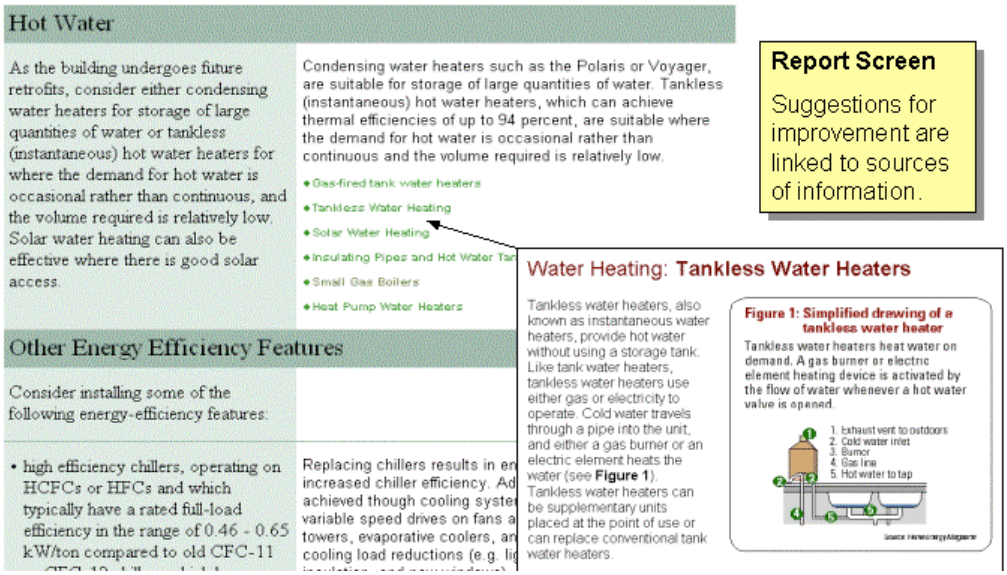

Figure 4. Sample recommendation screen

Benchmarking Potential

The software is also designed to generate quintile ratings, which provide a comparison with other buildings as well as with exemplary green buildings. It shows, for example, how energy values for one facility compare to other facilities and properties within the organization, within the immediate geographic setting and within the industry peer group. Without such initial information, it becomes difficult to identify those properties within a portfolio in need of immediate attention. Figure 5 illustrates how the assessment can identify a systematic problem across the portfolio or a problem specific to an individual building. An overall portfolio review will reveal the "energy or water hogs".

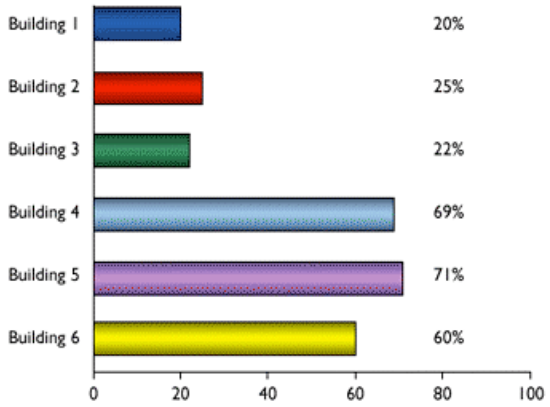

Figure 5. Sample portfolio review for water efficiency

A portfolio-wide review is often more acceptable than isolated building audits because senior management tends to take the strategic view that collecting, compiling and summarizing operating expense information about a portfolio of properties can lead to better decision making. By elevating energy and environmental management to a strategic initiative, there is an increased likelihood of obtaining senior management buy-in. Two conditions need to be met for this feature to be implemented. First a large enough sampling of buildings is necessary

in order to make meaningful comparisons with similar buildings. Secondly, the data must be verified by a third party to ensure reliable results. Assessors are licensed architects or engineers who have undergone either BREEAM or LEED training.

CONCLUSION

Green Globes is a reasoned response to mounting environmental pressures. Building owners and property managers need environmentally sensitive asset management tools and benchmarks against which to compare their portfolios. Thus, some type of environmental management system is needed. Synthesizing the best practices that are relevant to the majority of buildings by means of a simple checklist that can be completed in half a day, makes it an affordable tool that can be used in-house or with minimal help of a consultant. Using Green Globes as a first step can provide a seamless, vertically integrated assessment framework ranging from Green Globes self-assessment to a third party verified rating and a certification system with more stringent quality assurance elements, and finally to ISO certification.

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Greener Made Easy

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1. INTRODUCTION

Specifiers all over the world complain about how difficult it is to include environmental impact criteria when specifying materials for buildings and how hard it is to access sustainable materials, products and services. This paper documents the author's efforts over the last six years, to create an easy to use, coherent, focused set of tools which would provide information of practical use by a wide range of people operating in the building sector and enable them to access, select, obtain and utilise sustainable, environmentally friendly, materials, products, services and service providers.

This research resulted in three tools which aim to provide appropriate information at different stages in the specification process. The first tool is a set of *Building Element Life Cycle Environmental Impact Charts,* which are described more fully in a paper delivered to the CIB Task Group 8 conference *Buildings and the Environment* in Paris in 1997 (Storey). These outline, on a generic, comparative life cycle, basis, the environmental impacts associated with many of the materials commonly used in New Zealand buildings. These easy-to-use documents enable environmental impact to be taken into account when materials are selected during the initial stages of a building project.

The second component is a *Greener Building Directory*. This categorises, lists and reviews greener materials, products and environmentally or resource sensitive service providers operating in New Zealand. Each section and subsection includes an overview of the main environmental issues associated with the particular use category. This document allows the easy selection and accessing of materials, products which have less environmental impact than normal materials or products within their particular category. It also lists organisations which can help specifiers in the realisation of their project. This information is intended for use at the next stage of project development, developed design stage.

The final component is a *Greener Materials and Products Reference Collection*. This contains comparative data sheets, technical literature and where appropriate, samples relating to individual materials and products contained in the *Greener Building Directory*. This facilitates the closer scrutiny of materials and products prior to their final specification.

2. LIFE-CYCLE ENVIRONMENTAL IMPACT CHARTS

The first of these tools consists of a series of 20 Life-cycle Environmental Impact Charts which enable specifiers to take environmental impact into account at the initial stage of a project design. The need at this stage is to facilitate selection of generic rather than particular materials and to be able to do this on a basis which compares all the common materials used for a specific purpose. The central objectives were to make the documents readily accessible, easy to use and understandable with minimal explanation and to comprise New Zealand specific information. It was reasoned that only by fulfilling this criteria that laypeople and busy professionals would utilise the information.

Strenuous efforts were made to comply with these objectives and many features of the charts were specifically developed with these objectives in mind. The chart form was selected to make direct comparisons as simple as possible. Plain English was used to facilitate easy understanding. Descriptions were kept as short as possible, without losing meaning. The organisation and ordering of the charts was based on normal construction sequencing. The stand alone nature of each chart enabled concurrent use of the set by several people at once and minimises the impact of mislaying one of the charts. Information given is as accurate and dispassionate as possible. There is no attempt to rank one material relative to another, or to assign one environmental impact more importance than any other. This approach empowers specifiers yet lets them establish their own priorities and make informed decisions relating to the unique circumstances of the project under consideration. Each chart only contains information on a single layer of a building element. This approach enables virtually any combination of constructional materials in a particular building element to be considered, while minimising the number of charts required.

Considerable debate was held concerning the most appropriate format for this tool. In the end the hardcopy triple A4 chart format, which is folded down to A4 size for storage, was held to be the most useful and user-friendly mode for comparative study and selection. It has to be conceded that if the formatting decision were to be made today that it is likely that the internet would used. However, even if this were to be the case, it would still be desirable for the chart format to be retained. The advantage of web based documentation is that updating and upgrading, say by incorporating references or even the incorporation of direct links to further information and the Greener Building Directory, adding more materials to each chart, and adding new charts to the set would all be much more easily accomplished.

Observation by the author of the of the ease with which students, with only a very brief introduction, can use the charts to make reasoned, defensible, sensible and environmentally sensitive material selections, have been most gratifying. Unfortunately it has not been possible to carry out the same observations of the use of the charts in practice conditions. The recent introduction of compulsory Continuing Professional Development for architects in New Zealand does however give rise to some interesting possibilities for running workshops on the use of the charts in the future.

3. GREENER BUILDING DIRECTORY

Once generic building materials are selected, and work progresses to detailed design stage specific materials and products are usually selected. It is at this point that the Greener Building Directory becomes useful. In essence the Greener Building Directory is a listing of useful service organisations and materials and products which are ‘greener’ than the norm in the categories covered.

The document started life in 1999 as a hardcopy booklet entitled “The Wellington Materials and Products Directory” which was literally a listing of ‘greener’ materials and products available in the Wellington region of New Zealand and where you could obtain them. In successive iterations an organisations section was added and an introductory section was added to each use category describing the main associated environmental issues. In a further issue the scope was made national. In all cases the ordering of the materials section was the same as the ordering of materials in the life-cycle environmental impact charts.

In 2001 the decision was made to convert the Directory into a web-based tool. At the same time, in order to facilitate comparison and selection, all the descriptions of materials and

products were reorganised under five headings: environmental impact, sustainability, energy, health, other environmental data and each category was given its own symbol. This change to web based publishing means that contact details can be changed and information added and subtracted at will. Previously this was impossible between printings and contact details in particular became rapidly out of date.

The problem is however that the sale of the hardcopy version to users enabled the Directory to be financially sustainable. We could try to initiate some sort of user pays system such as an annual user registration fee for access to the web page but feel that this would inhibit its use by the general public, which is something we are keen to encourage. The current thinking is get manufacturers and service organisations to pay a yearly listing fee. However we are very conscious of the potential dilemmas that this could bring. For example, we want the Directory to be as comprehensive as possible, so if a company does not pay, do we remove the listing or not? What happens if the company seeks to change the description of their product in consideration of the fee they are paying? Larger companies may want to want to add photographs or direct internet cross links to further information on their products, for an additional fee; this adds to the value of information contained in the Directory but privileges large companies over smaller or less wealthy companies whose products may be just as good or even better than their richer competitors. In each of these cases the integrity or equity of the Directory can be compromised. Therefore before definitely committing to this fee structure we are also examining the possibility of obtain sponsorship from organisations outside the building sector and who are therefore less likely to wish to interfere editorially with the product.

4. GREENER MATERIALS AND PRODUCTS REFERENCE COLLECTION

This is a collection of technical literature, and where feasible samples, of all the materials and products contained in the Greener Building Directory. The idea here is to enable specifiers easy access to detailed information and be able to compare physical specimens of the listed materials and products. This is especially important in a country like New Zealand where many of the architectural and interior design practices comprise one or two people and where consequentially practice technical libraries are fairly rudimentary. The collection is lodged in the Schools of Architecture and Design library of Victoria University of Wellington. It is accessible by all students, practitioners and the general public.

Two of the fundamental problems are how to maintain the currency of the information and the fact that physical access is only available to those able to come to Wellington. As this information is available to the students the Schools' librarian has expressed a willingness to house and give operational support to the collection, but does not have the resources to systematically contact all contributors on a periodic basis to ensure that the collection remains current. Therefore whatever the financing system adopted, someone must be employed to carry out this task. This is however seen as requiring only a few hours once or twice a year. It may be simplest to maintain currency in the situation where each of the listed companies is required to pay an annual fee and updated information and samples might sensibly be provided as part of the fee paying process, when the company can immediately distinguish a benefit from their fee. The problem of giving specifiers access to samples on a nationwide basis remains intractable but it should be possible to scan the trade literature and make this available on the internet.

Most company literature is really sales information, where the technical content is low and information on the range of materials in any use category is very rarely uniform enough to

permit comparative consideration by specifiers. Therefore a set of descriptor sheets which give detailed information under the same five headings as are used in the Greener Building Directory, are being produced with the objective of facilitating comparison of all the materials or products within a particular use category. These sheets will contain information provided by the manufactures but are intended as comparison not as assessment sheets. Assessment is beyond the intention of this set of tools or the current resources of the University. Separate environmental assessment of materials and products is not currently carried out in New Zealand.

5. FUNDING

Funding has been problematic throughout all three phases of the programme. In the early stages of the research into the life cycle environmental impact charts no funding at all was available and students from the principal author's 'Green Architecture' course were pressed into service to carry out the initial research into the environmental impact of materials commonly used in New Zealand. The results of this work were very variable; both due to the different levels of understanding and effort put in by the students and by the varying degrees of cooperation received from manufacturers. In time a small grant, about 5500 euros equivalent, was secured from the Ministry for the Environment's Sustainable Management Fund, the New Zealand Institute of Architects agreed to publish the Charts and manufacturers were persuaded to cooperate. Storey was able to use part of his Research and Study leave to carry out work on the programme and a series of nation and international experts persuaded to donate their time to act as referees.

A similar pattern has been followed in the case of the Directory and Reference Collection tools. Here however funding has been provided by the University's Small Grants Scheme. The total value of the grants has been 6000 euros equivalent over five years which has been gratefully received but has proved to be a major constraint on the development of these tools. With the timescale involved a series of student research assistants have had to be employed and that has meant that roughly 10% of the grant has been used in familiarising them with the programme requirements and undertaking their educational emersion in this specialised research activity. A further 20% of the grant has been utilised to pay for faxes and toll telephone calls.

Financing the ongoing maintenance, upgrading and expansion of the three tools is at the time of writing still unresolved, but is receiving urgent attention from the author. Looking back, while this research demonstrates what is possible on a very low budget, with the good will, commitment and tenacity of all involved, it is not a path that the author would willingly tread again. More time and effort spent by Storey in searching out funding sources would probably have been a more sensible use of his time, though less appealing, than doing work on the research itself.

6. FURTHER WORK

All three tools though useful both singly and collectively in their current states are seen as works in progress. Thirteen life cycle impact charts are needed to complete the set. After five years all the existing charts are in need of review, updating and upgrading. Due to the insistence by the NZIA that they would carry out the final printer's proof reading, a small but significant number of errors also crept into the charts and these also need correcting. The most significant upgrading would be to republish the charts as a web page. However the NZIA currently hold the copyright and some accommodation would have to be reached with

them before progress can be made in this area. Once on website it becomes much easier to correct the documents, and update, upgrade and add to the set on an incremental basis. It would also enable the adding of references and links to the other tools in the set.

One of the things that the author struggled with in generating the Directory and the Reference Collection was the constant stream of changes that occurred, particularly in contact details but also in being made aware of new materials and products coming onto the market and others being withdrawn. It became clear that whenever the hardcopy version of the Directory was published it would be out of date before it went on sale. This was in the end the most persuasive argument for converting the material into a website, despite the financial problems this has created. Raising finance is really the key, and this is much more hopeful in the current political in New Zealand climate than it has been for number of years.

7. CONCLUSION

The primary intentions of these working tools was firstly to empower specifiers to access, compare, select and specify greener materials and products and put users in touch with organisations which could be helpful in translating resource sensitive, and environmentally and ecologically friendly intentions into physical artefacts. The second intention was to do this in a simple, easily utilised way which allowed the specifier to apply their own set of values to the selection process rather than foisting the author's own set of values on the specifier, either overtly through the use of preferential language used in descriptors or covertly through the adoption of some sort of less than transparent assessment system. In this the author feels that the tools as developed do in fact meet the strict criteria set.

Different types of information are needed by specifiers at different stages during the development of a project and the tools were designed to provide this. Therefore they are organised hierarchically from the general, the generic life-cycle charts; to the particular; the comparative information sheets in the Reference Collection. However it is possible to easily access any or all the tools without having to go through the other tools. The use of the tools is essentially self evident. This is quite deliberate and is intended to make the tools simple and easy use by busy people although 'how to use' sections are provided in each of the documents.

It is acknowledged that all three tools remain works in progress and hopefully that will remain the case, as the intention is that they can and will be updated, upgraded and added to over time. The tools are however not as comprehensive in their scope as the researchers would wish, due to the severe financial constraints under which this research was undertaken and this is less satisfactory. It was decided however to launch the tools with the material currently available, on the basis that some information was better than none and no compromises in the accuracy or quality of the information provided was countenanced. Work continues to expand the materials and products included in the Directory and the Reference Collection. Expanding the offerings in the Environmental Impact Charts is harder due to the copyright issue outlines above. The situation relating to the Charts is seriously inhibiting the full integration of the tools particularly in relation to the hierarchical links between generic and proprietary products and will have to be addressed in the near future.

The current financial situation is quite unsatisfactory and is currently being addressed as a priority item. It is considered vital that finance should come from more than one source as otherwise the programme becomes too vulnerable to the withdrawal of this funding. Long term sponsorship, charging manufacturers and consultants their entry, after a free introductory period, government and private grants are all being investigated currently. The

notion of charging users on the internet through a registration fee is being resisted as there is a desire to encourage the widespread us of these tools amongst both professionals and the public. There is also the intention to produce and sell hardcopies of the data for those people who do not have access to the internet and for organisations like libraries that wish to hold hard copy sets. The intention here is to keep the selling price as low as possible so that use is not inhibited.

A number of future problems are foreseen and solutions are being developed. A number of people already telephone the author concerning the selection and specification of materials. It is likely that this will increase over time. Consideration is being given to charging for this advice, through a time charge telephone number which will have the effect of reducing casual callers, but in fact the author does not have the time to act as a helpline consultant in these matters. There is also the possibility that legal action could occur if anything went wrong, something which is much more likely when advice is given over the telephone rather than in a more conventional consultancy situation.

The other challenge is to try to streamline the data updating and billing arrangements. A cache address to which people can send comments, updating information and ask for their materials or products to be included in the Directory is part of the website and will be cleared at periodic intervals. It is hoped to send out requests for confirmation of entry data and up to date technical literature and fees in a single exercise once a year. However we have not as yet tried out these arrangements and they may well have to be modified in actual practice.

Having developed the webpage tools it is easy to see the attraction of a do, publish and forget hardcopy tool. The extra complications of producing, administering and managing a set of web based tools as outlined in this paper almost, but not entirely, outweigh their positive attributes. It is suggested that this set of tools is a technical success, but finance is now the key. If it proves possible to access the long term funding sought, it is likely that this set of tools will become ever more useful. Without such finance the tools are likely to depreciate in value over time and will eventually have to be withdrawn and abandoned. However, which of these two scenarios eventuates, only time will tell.

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Greening Greater Pittsburgh: The Transformation of a Region

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1. INTRODUCTION

James Parton once referred to Pittsburgh as "hell with the lid off." Years of industrial success had left the human and natural environment a legacy of pollution – at times the Monongahela River had topped 120 degrees Fahrenheit. While such pollution had once been seen as a sign of prosperity, citizens began to declare that smoke was no longer an acceptable byproduct of a healthy economy. It was evident that a merging of economic and environmental interests would be a necessary strategy for the future of Pittsburgh. Under the leadership of Mayor David L. Lawrence and industrialist Richard King Mellon, the first Renaissance of Pittsburgh began in the 1940's lasting until the late 1960's. After much success in creating some of the nation's leading pollution control laws and strategies for redevelopment of areas no longer dedicated to heavy industry, Renaissance II was born. The second Renaissance built itself on the foundation of the laws and planning efforts of the earlier decades focusing on economic development more than restoring the natural environment. New communities were planned for many of the sites left idle on the riverbanks of Pittsburgh.

As Pittsburgh moves into the 21st century, sustainability is the focus of many of the civic leaders throughout the region, although a consensus has yet to emerge among the diverse leadership within the community on what sustainable development means to Pittsburgh. For the Green Building Alliance, Sustainable Pittsburgh, the foundation community, among other civic leaders, development that balances economic, social and ecological health is the only way to ensure a legacy of prosperity for both the human and natural environment. This case study will provide a snapshot of how the environmental transformation of the Greater Pittsburgh region has set the stage for economic success.

2. HISTORICAL OVERVIEW

2.1 Renaissance I: 1946 -1969

Under the leadership of Mayor Lawrence and Industrialist R. K. Mellon and with strong support of the city's top industrialists, businessmen and educators, the first Renaissance was born. Over the next twenty years civic agencies like the Allegheny Conference on Post War Community Planning (now known as the Allegheny Conference on Community Development – ACCD) and the Urban Redevelopment Authority of Pittsburgh (URA), began work to improve the city and

plan for its future. The Commonwealth of Pennsylvania also participated in the effort to return quality to the life of the region. Redevelopment included the creation of Point State Park at the confluence of the rivers in the heart of downtown and the rebuilding of downtown Pittsburgh's "Golden Triangle". By the end of Renaissance I, the city and region had one of the nation's first smoke control laws and a strategy for flood management; positioning Pittsburgh at the top among industrial cities for redevelopment.

2.2 Renaissance II: 1980's

Once a world leader in production, Pittsburgh's steel industry was now faced with serious changes in the economics of steel production and foreign competition. By mid-1980, the industry began to close its doors. While tensions mounted over the decline in domestic steel and whether stringent environmental laws had unfairly hindered companies competing with foreign giants, it became clear that the industry was waning. As companies began shutting down production, large landscapes along the three rivers lay idle. Families throughout the region were grappling with more than 100,000 jobs lost and community leaders were faced with a series of challenges. Pittsburgh once again needed to align its economic and environmental goals. Civic groups began planning with development agencies for clean up and redevelopment. Public-private partnerships became the strategy of the 1980's for providing the massive infrastructure needed to attract private development to these large sites. Pittsburgh worked closely with the Commonwealth of Pennsylvania to enact legislation for remediation and liability issues associated with previously contaminated sites. Several sites took advantage of the legislation and now offer a new urban place of housing, retail, office and natural amenities.

2.3 Renaissance III: 2000 and beyond

The new millennium marks 50 years of progress in Pittsburgh's renewal and redevelopment, despite the constraints of a slowed economy, severe job and population loss and a dwindling manufacturing sector. While historical groups like the Allegheny Conference remain active and effective, they are augmented by other entities focused on sustainable development as the primary goal for our Renaissance III. The following is a sampling of the many projects and programs that together form Pittsburgh's newest Renaissance, once again coalescing economic and environmental agendas. To quote President Bush during a recent visit, "Pittsburgh is no longer a steel town-- it is a knowledge town." Pittsburgh's success in the new millennium will depend heavily on its natural amenities, access to recreation, the strength of its major universities and its low cost of living to attract the workers of the 21st century seeking a high quality of life.

As in previous decades, there are many organizations that have major initiatives focused on sustainable approaches to development. This paper profiles several projects and programs in an effort to demonstrate the opportunities for Pittsburgh to lend its lessons to the world once again. They are considered to be a representative sample of the myriad of efforts throughout the southwestern Pennsylvania region working towards a sustainable future.

2.3.1 Green Building Alliance. GBA and its many partners—foundations, universities, private corporations, professional associations, government agencies and other non-profits—have strategically driven the market for green building in the Pittsburgh region at a pace beyond that of any other area in the United States. According to Christine Ervin, president of the U.S. Green Building Council (USGBC), Pittsburgh is "a hotbed of this activity … and has set an enviable pace for green development." GBA has provided technical assistance and educational

opportunities to two key projects: The New David L. Lawrence Convention Center and PNC Firstside Center. Its programs and projects of several key organizations form a network that has created one of the most comprehensive programs in the country.

2.3.2 Sustainable Pittsburgh. The challenge of growing the Pittsburgh region encompasses both the economy and the environment and is inclusive of all members of the community. Sustainable Pittsburgh is designed to lead the region towards a future that embraces planning and policies that balance economic growth with natural resource conservation; cooperation among communities in the region; and education to provide the skills and tools to make the transition to a sustainable community. On Earth Day 2002, Sustainable Pittsburgh will release the region's first set of goals and indicators based on the tenets of sustainability. Community leaders will then work to integrate these into the region's mainstream development strategies, and to create a vision that establishes sustainability as a key criterion in community decision making and long term planning.

2.3.3 Riverlife Task Force. In 2000, civic and business leaders created the Riverlife Task Force because something important was happening along Pittsburgh's three rivers: after decades of neglect, they were being rediscovered. Plans were underway for two new sports facilities, new parks and trails, and large-scale development projects. What inspired many to initiate the Task Force was a desire to see the evolution of the three rivers to resemble principles of good civic design. For example, Principle 9 urges planners and developers to embrace the concepts of sustainable development. Riverfront development is encouraged to celebrate the pedestrian urban lifestyle in harmony with the environment while fostering regional economic growth. And, that development along the rivers ought to employ green design strategies such as energy and water conservation, storm water management, and native landscaping. After two years of community planning, Pittsburgh now has a renewed imagination for the future of its riverfronts.

2.3.4 Three Rivers – Second Nature. A project of 3 Rivers Wet Weather Inc., a group established as a public-private partnership to design and demonstrate solutions to the historic wet-weather, sewage-overflow problems of southwestern Pennsylvania. Over the next decade, 3 Rivers will be guiding hundreds of millions of dollars in regional infrastructure capital project investment by state and federal government agencies. Most proposed solutions are large, costly concrete treatment plants or sewer lines. As alternatives to highly engineered facilities, 3 Rivers seeks to create innovative, ecologically based solutions through a partnership with the STUDIO for Creative Inquiry at Carnegie Mellon University and local environmental scientists. The STUDIO's model of creative inquiry, ecosystem analysis and community dialogue resulted in a highly regarded and feasible solution to the degradation of Nine Mile Run. By developing appropriate ecologically based site alternatives, the project will conduct public outreach and education, establish a baseline for water quality and biodiversity within the Pittsburgh Pool and develop a geographical information system to guide decision making.

2.3.5 Southwestern Pennsylvania Plan for Natural Amenities and Green Infrastructure. Planning is currently done for such specific infrastructure needs as transportation and sewer and water. The goal of the Green Infrastructure Plan is to create a detailed map of the natural landscape and its relationship to human settlement. The plan will recommend ways to develop and promote recreational opportunities, conserve important natural areas, and direct new growth to less environmentally sensitive lands. Within three years, this plan will provide the basis for

prioritizing future investment by the public and private sector in conservation, recreation, and development. Ultimately, it will allow the region as a whole to prepare a comprehensive plan for how we integrate land use, amenities, ecology, and transportation and sewer and water infrastructure to guide the future of southwestern Pennsylvania. A strategic plan with specific recommendations for actions, priorities, timeline and funding implications will ultimately inform conservation and land use decision-making. A framework for site impact analysis will assist the public and non-profit sector seeking to understand where and how development should occur. Data gathered to inform the plan and to create a regional geographical information system would ultimately be integrated into SPC for use by planners, conservationists, public agencies, private developers and the general public.

2.3.5 Green Neighborhood Initiative. The Green Neighborhood Initiative is a project of Conservation Consultants, a regional non-profit organization specializing in energy efficiency, environmental education, and sustainable urban redevelopment. Since 1995 the program has provided free energy and water conservation surveys to homes, businesses, religious organizations, and community buildings in four urban neighborhoods: Carrick, Knoxville, Lawrenceville and the South Side. Based upon level of implementation, utility savings range from 10% up to 50%. Money saved is used as an economic development tool and put back into the community. Energy efficiency conserves natural resources and reduces air pollution. The seven working categories of the program are: Housing, Business/Industry, Religious Organizations, Schools, Lead Education/Risk Reduction, Neighborhood Beautification and Historic Preservation.

3. BUILDING CREATIVE PARTNERSHIPS

As was the focus of the first two Renaissances, public-private partnerships remain key to delivering an effective project. With Pittsburgh having the highest level of foundation support per capita in the U.S., the philanthropic community is often found as a driving force behind the boldest initiatives. The Heinz Endowments in 1994 created an environmental grantmaking program, which has given more than $100 million in grants to area organizations. The focus has been to foster sustainable urban design, environmental enterprise and watershed protection and ecosystem restoration. As each grant is considered, the foundation looks to see how the proposed project fits within the goals and the outcomes it suggests to seek. Since 1994, Heinz has been largely responsible for catalyzing the modern green building movement in Pittsburgh, among other major initiatives described earlier.

Another key player has been the Commonwealth of Pennsylvania. Together with the Department of Environmental Protection and the Department of Conservation and Natural Resources, the Governor's Green Government Council has made significant strides in overlaying natural resource conservation targets within each governmental agency. For example, Pennsylvania has prepared a requirement that all government buildings meet the LEED™ certification criteria. And, the state has pursued sustainable forest certification for all state owned forests under the Forest Stewardship Council's guidelines.

4. CONCLUSION

Meeting the challenges of building sustainable communities requires balance between economic growth and environmental protection. Sustainable communities also recognize the linkages between the economy, the environment and social consequences of decisions. Key strategies

include the identification of best practices that demonstrate effective models of integration of the environment with community and economic development goals. The concept of sustainable development is emerging front and center in Pittsburgh. The term describes a mix of approaches to improving the economy, the environment, education, quality of life and local communities. For the region sustainable development strikes at the core of many of society's ingrained and inefficient behaviors involved with how we live, construct our homes and neighborhoods, build our businesses, and use our open space. And it is driving many of the strategies of the region's private, public and non-profit organizations towards a sustainable future for western Pennsylvania. These strategies emphasize:

- Revitalization of the urban core through environmentally-sound development, reuse of former industrial sites, support of affordable housing and preservation of green space;
- Increasing business and governmental efficiency to facilitate progress towards environmental protection and economic growth; and
- Community-based education and outreach programs that seek to strengthen the region's social fabric by linking people to schools, communities and planning processes.

Pittsburgh is making the transition from an industrial based to knowledge-based economy. Fortunately, early leaders and visionaries saw the need to make environmental improvements in conjunction with economic stimulators and public-private investment.

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Greening Pittsburgh's new Convention center: Tales, Tools and Transactions

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1. INTRODUCTION

Pittsburgh's *new* David L. Lawrence Convention Center (Center) will be the first of its kind in the world to fully integrate the Leadership in Energy and Environmental Design (LEED) ™ rating system. Named for the former mayor of Pittsburgh who led Renaissance I, in which he connected environmental quality with economic development, the Center is an icon representing the region's environmental transformation over the past fifty years. The greening of the Convention Center is truly a project that coalesces the elements of sustainability for the 21st century.

Greening a building of this size and complexity is not easy for many reasons. The Center seeks to be a sophisticated urban building that celebrates its relationship to the riverfront, the adjacent historic and cultural districts, the natural environment and transportation modes, and to respond to diverse demands. The local governments responsible for building the Center originally intended to hire a design-build team without going through a publicly conducted competition. As a result of many points of interest, the government was compelled to conduct a design competition that would ultimately result in the selection of an internationally known architectural and engineering team, and make the Center the icon so many desired for Pittsburgh.

Once the design team was selected there were several groups of professionals assigned to track various components of the design and construction process. With the difficulties of a public bid process, tight budget, fast track schedule and politics, the challenges have been numerous. This paper is intended to provide a snapshot of the greening process, challenges faced, and how opportunities were seized to ensure the delivery of a successful green building.

2. PROJECT OVERVIEW

The Center is located on a 3.2- hectare urban infill site along the Allegheny River within the central business district and adjacent to the cultural and historic districts of Pittsburgh, Pennsylvania, United States. The new 140,000 m^2 Center will be completed in March 2003 at a cost of approximately $354 million (USD). The owner of the Center is the Sports and

Exhibition Authority (SEA), a joint public authority of the city of Pittsburgh and Allegheny County governments. The Center was financed primarily with funding from Pennsylvania's capital budget and bonds issued against revenue from the local hotel tax. At the will of the General Assembly of the Commonwealth of Pennsylvania, the Southwestern Pennsylvania Convention Center Design Commission (Design Commission) was created to participate in and approve of the design team selection and subsequent processes related to design and construction. The fifteen-member Design Commission included representatives from the hospitality community, along with political appointees.

With encouragement from the local foundation community and support from the state and SEA Chairman Tom McCargo, the Design Commission undertook a two-part selection process. First, a request for qualifications (RFQ) was issued and resulted in responses from twenty-five internationally known architectural firms and seven finalists. Second, four firms were invited to participate in a design competition, with each receiving a stipend of $100,000. The total cost of the design competition process, $750,000, was funded by several Pittsburgh-based foundations under the leadership of The Heinz Endowments. This was the first design competition conducted for a civic building in Pittsburgh since the H.H. Richardson Courthouse at the turn of the 19th century. Through the Convention Center process, the Design Commission and Heinz hoped to set a new standard for civic design, while also demonstrating that it could bring a better comparative result—in this case, a world-class building that is functionally, aesthetically, socially and ecologically prominent.

3. THE GREEN DESIGN PROCESS

3.1 Getting Started

The process of greening development projects is an important case study in addition to any technologies used. As for all projects, the decisionmaking process that led to the selection or rejection of green technologies or strategies for the Center was critical. Many of these steps would arguably be standard for projects where team members and owners are not familiar with or fully committed to green building.

In 1996, the concept of a green center was discussed between key people at The Heinz Endowments, the Green Building Alliance (GBA) and the Public Auditorium Authority (later known as SEA) prior to the formation of the Design Commission or the architect selection process. An important first step in the concept's implementation was the appointment of Rebecca Flora, GBA's executive director, to the Design Commission. This placed a green advocate inside the decisionmaking structure. The second step involved receiving significant support from the local foundation community, which was used to carry out the design competition, for technical assistance, and outreach and documentation for maintaining the project's goals. As the Design Commission proceeded to incorporate green criteria into all aspects of the request for qualifications (RFQ) and design competition processes, design teams were compelled to respond to green design goals. The RFQ was issued in July 1998.

3.2 Selecting the Right Team

The Commission used the RFQ process as an opportunity to include additional professionals representing functional aspects of the building, including two members of the Pittsburgh Chapter of the American Institute of Architects, Marsha Berger and Alan Weiskopf; the head of the School of Architecture at Carnegie Mellon University, Vivian Loftness; and long-time international green architect, Robert Kobet. The responses to the competition process were astonishing, including everything from green roofs to daylighting and natural ventilation. In

February of 1999, the design competition jury unanimously selected Rafael Viñoly Architects (RVA) and Burt Hill Kosar Rittlemann Associates (BHKR), whose swooping roof design provided a perfect fit for natural ventilation along the Allegheny River. The Butler, Pennsylvania office of BHKR served as the lead engineer for the project and proposed many green concepts, such as a water reclamation system that would later become an essential strategy towards the achievement of a LEED™-certified building at the Gold level.

3.3 Identifying a Green Champion

The RVA submission was not only the best design, but it also responded most holistically to green design principles. Taking a design from concept to construction, however, would require a champion to maintain green as a priority in the project. Since BHKR was hired primarily to be the mechanical, electrical and plumbing engineers—not to execute the green components—this left the project without a clear manager or adequate technical assistance for green design. In 1999, the Green Building Alliance, with funding from The Heinz Endowments, became the project's green champion.

Building green is not easy. A project of this size and complexity requires constant oversight to ensure that no opportunity is lost and that others are maintained. A project matrix of the green strategies agreed upon to meet the LEED™ criteria for certification was created and used at weekly project meetings. After several months, Heinz, GBA and other team members urged SEA to create a Green Team to ensure that the project would remain on track for certification at the Gold level. This group met monthly and was staffed by Gary Goodson of GBA, who also served as the first green agent for the team. Any project team member who is responsible for implementing strategies under the LEED™ submission attends the monthly meetings. The green agent role has evolved to a shared responsibility between Mr. Goodson, John Patten (RVA project manager via BHKR) and Harry Gordon (BHKR's green specialist).

3.4 Partners and Resources

Active participation by The Heinz Endowments was a key component of success for this project. Heinz not only advocated and funded the design competition, but they also provided an $800,000 grant for advocacy and technical support to the greening process, as well as offering a $3 million loan to the public authority, if needed, for green strategies with life-cycle savings or demonstration benefits to the project. While the funding was instrumental, active participation by Melisa Crawford of Heinz was equally important on the Green Team, in monthly project meetings, and in the overall project. Another helpful lever was the Pennsylvania (PA) Commonwealth's requirement of the use of green technologies in exchange for their commitment of $149 million to the project. The PA Department of Environmental Protection monitored this criterion, lending support to the Green Team when needed. As the project progressed, the marketing aspect of the green convention center became an additional lever. The Greater Pittsburgh Convention and Visitors Bureau discussed the green features in its marketing materials to distinguish Pittsburgh from other cities and to establish a competitive edge for its Center.

3.5 Establishing Goals and Reaching Consensus

At the time of the project's initiation, local government, the building industry and many team members did not support green. This situation improved after many workshops and project meetings that drew the design team towards the LEED™ Gold rating. There were still many struggles and barriers to achieving that goal, however, due to first costs, a tight schedule, maintenance, and lack of support and/or distractions from other issues faced by team members. Development realities such as value engineering necessitated ongoing support from

GBA and Heinz, while the extensive process, technical assistance and required funding were considered necessary to keep the project on track. The education component of this effort will continue with extensive project documentation and performance evaluation.

At the beginning, a full-day goal setting workshop organized by GBA was conducted using the LEED™ rating system. Ms. Flora and Bill Browning from the Rocky Mountain Institute facilitated the workshop, which prepared the project team for pursuit of green building concepts and the LEED™ process. Follow-up opportunities were provided through on-going GBA technical training workshops, including commissioning, green specification writing, construction and demolition waste recycling, and LEED™ principles. During design development, GBA organized a 2-day peer review process, funded by the Pennsylvania Department of Environmental Protection. The resulting peer review report provided recommendations, such as the need for a lighting consultant and additional modeling.

3.6 Technical Assistance

Since there was no other major green building in Pittsburgh in 1998, Heinz saw the convention center as a prime opportunity to demonstrate the feasibility of building green and, therefore, significant support for technical assistance was ensured. Using a multi-year grant from Heinz, GBA provided the project and its team members with a variety of in-kind services and access to technical resources that would normally be unavailable to similar project types. Technical assistance and consultants were provided to the convention center team for energy and daylight modeling, specifications writing, commissioning, and construction waste and demolition recycling. In 2001, GBA funded an interim LEED™ review and report that was conducted by Paladino Consultants. This review provided additional direction to the team regarding LEED™ requirements, as well as what would be necessary to stay on track for a gold rating.

3.6.1 Modeling. Accurate computer modeling of unique building types requires superior skills with modeling software that the majority of design firms do not have among their staff. BHKR first used a software product called Trane TRACE® for the Center. Although the Trane Corporation makes this product available, using software from an equipment manufacturer is not always the best way to optimize mechanical systems. Significantly improved modeling tools are typically based on DOE 2 software, and the utilization of the best available modeling software and technicians can save money on first costs and operations.

Computer modeling was used to estimate the building's energy use and amount of daylight. GBA first received support from the U.S. Department of Energy (DOE), who lent one of their top energy-modeling experts, Vladimir Bazjanac from Lawrence Berkeley Labs, to assist with daylight and energy modeling. The Constructive Technologies Group (CTG) was later hired by GBA to continue the energy modeling work, and the design team hired Lam Partners to complete the daylighting study.

As the team sought to optimize the cooling load capacity of the building, the owner insisted that the Center be capable of maintaining set points for any use, including an ice cream convention in August. As a result, the engineering firm had a disincentive for optimizing system capacity, as they would be liable for unforeseen loads. This is especially challenging with a convention center that has such a wide variety of uses. BHKR originally estimated that the Center alone would require about 5,000 tons of cooling capacity; however, GBA wanted a more precise estimate of what the peak capacity needs were likely to be. Between the use of

DOE 2, Vladimir Bazjanac, and CTG, the Center's geometry, a challenging figure to obtain due to a curved roof, was established. When the complete analysis was finished it indicated a peak cooling load of just 2,700 tons, 46% less than the original estimate. This difference in professional analyses led to a spirited debate. In the end, 6,000 tons of cooling capacity was specified to provide chilled water for the Center and an adjacent hotel.

3.6.2 Commissioning. The value of commissioning was hugely debated among members of the design and owner teams. Had the LEED™ system not offered points to employ a stringent program, third-party commissioning would have been value-engineered; however, GBA remained concerned that commissioning requirements would be lost in the contractor specifications before a firm was selected. Because of GBA's intervention and Mr. Goodson's service as a green champion, the project owner issued an RFP and hired a commissioning agent to prevent costly change orders later in the process. CH2M Hill was selected to work with BHKR, who commissions their own projects at no additional cost. A total of $217,000 was required for CH2M Hill's involvement, of which the SEA provided $50,000, the PA DEP $100,000, and a local foundation $25,000 (in grants). The remaining amount was paid by GBA, and the commissioning plan is currently being implemented.

3.6.3 Specification Writing. To ensure consistency, LEED™ requirements were written into the specifications. This task was completed by GBA and BHKR. The RVA design team challenged the green team several times as green elements were removed from the specifications. In the end, most of the bid packages required the contractor to meet the LEED™ standards, but significant follow up was still needed since many companies did not submit the information as requested. In the future, having model LEED™ specifications would be very useful.

3.6.4 Construction Waste Management. Over 95% of the demolition waste (by weight) from the original convention center was recycled. The owner was initially skeptical that the old center could be recylced, even after GBA held a construction and demolition (C&D) waste presentation and paid for a study by Wilmot & Associates (a C&D waste recycling company). The owner was concerned that the demolition company would not have space for a crushing operation on site and/or that the contractor would not have a customer for the fill. They agreed, however, to let GBA write the specifications for this effort.. The winning bidder, A&L, used the old Center's drop-off parking lanes to site the crushing plant. The demolition company was able to increase their revenues by selling clean fill for $4.75-$5.25/ton. Some of this fill was used on-site. The only cost increase was $10,500 for documenting the recycling effort, as required for LEED™, while one disadvantage was that it took longer to process the materials on site than expected. Construction waste recycling is ongoing.

3.6.5 Water Reclamation System. The Center's water reclamation system is projected to reduce potable water use by over 75% and BHKR led the charge on this technology for the project. While the "simple" payback for the system will be about 15 years, both Heinz and the Green Team felt that such a large and important building should demonstrate the value of our potable water resources and ways they can be conserved. For those reasons, Heinz emphasized exemplary water conservation as a condition of their loan.

3.6.6 Day Lighting. Daylight will blush 75.5% of the Exhibit hall space (21,972m^2 of the total 29,084m^2), which, for a United States convention center, will be quite unique. While studies have indicated improvements in productivity and sales of merchandise from natural lighting, focus groups of convention center users did not widely embrace the concept. The

primary concern was over the ability to darken the space as needed. Shading devices are now part of the design, but at $4.3 million dollars they negate some of the earlier savings projected by the daylight modeling. Occupant and daylight sensors also are being installed and are expected to have a payback of less than two months.

3.6.7 Aquifer Cooling. With 6,000 tons of peak cooling capacity, the number and size of cooling towers needed for the Center is immense. At one point in the design process it was proposed that the aquifer could actually be used instead of cooling towers. This substitution would have decreased structural steel and shrouding to hide the cooling towers, and would have eliminated the plumes of water vapor coming from the towers. Although Pittsburgh is blessed with large quantities of groundwater flowing under the Center, since the cooling plant was contracted to a third party it became difficult to pursue this concept. As an alternative strategy, GBA helped the Center obtain a pollution-free cooling tower water treatment system.

4. CONCLUSION

The greening of the David L. Lawrence Convention Center presents many learning opportunities that will serve to educate the future of green building in Pittsburgh and beyond. The project will also bring worldwide attention to all that the city is doing in the environmental arena. The Green Building Alliance has played a unique role in this process, serving as champion, facilitator and technical assistance provider to the implementation of green design strategies. The Center has become a primary example of green principles, as the building industry in Pittsburgh and Pennsylvania seeks to adopt and mainstream similar design concepts into the marketplace. The challenges in this project have been numerous and will be further documented as part of an electronically-based “lessons learned” publication, which will be produced by the Green Building Alliance with support from the Heinz Endowments. This paper was intended to provide insights into the complex process of greening a large, publicly-owned facility in the United States.

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Residential Street Pattern Design

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INTRODUCTION

Streets connect the private with the public domain and also link different parts of a neighborhood. These linkages support social interaction and exchange—both vital urban functions. Street design can contribute significantly to the quality and character of a community. Well designed streets create safe, quiet and healthy environments, particularly for children.

Current thinking on street pattern design is divided between concern for infrastructure and transportation efficiency, and neighbourhood quality. This generally translates into a battle between proponents of conventional suburban loops and cul-de-sacs, and those of "traditional" grids. The latter approach is typified by Smart Growth, New Urbanism, and Neo-traditionalism. This paper proposes an alternative to both these street pattern models, one that balances efficiency and quality. The design process involved incorporating the positive attributes of conventional suburban development while taking into account today's technology and consumer preferences.

EFFICENCY AND QUALITY

Street Efficiency. Efficiency in land and infrastructure development can be achieved by combining two standard street types: loops and cul-de-sacs found in the post-war suburb and long blocks common to grid and conventional suburban layouts. Contrary to popular opinion, the curvilinear street pattern associated with conventional suburban subdivisions is not inefficient. In fact, for comparable residential densities, loop and cul-de-sac street patterns are more cost efficient than a traditional gridiron geometry (which is why they are preferred by most developers). According to the technical literature on street planning, conventional suburban street layouts consume 16-25 percent less land than the traditional grids advocated by New Urbanism (see Fig. 1.)

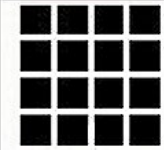
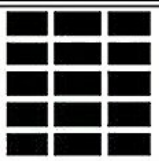
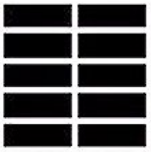
	 Square Grid. (Miletus, Houston, Portland etc.)	 Oblong grid. (most cities with a grid)	 Oblong grid 2 (some cities, or in certain areas)	 Loops. (Subdivisions - 1950 to *now*)	 Cul-de-sacs. (Radburn, 1932 to *now*)
Percent of area for streets	**36.0%**	**35.0%**	**31.4%**	**27.4%**	**23.7%**
Percent of buildable area	**64%**	**65%**	**68.6%**	**72.6%**	**76.3%**

Figure 1. Comparison of area used for streets, among five typical street patterns.

Traffic efficiencies can also be attained by a creative combination of loops and cul-de-sacs, and grids. Loop and cul-de-sac street patterns have evolved since their beginnings in Radburn in 1928. Their geometry has been easily adapted to the automobile by excluding traffic at the local street level, and permitting good flow at the collector and arterial levels. However, the loop and cul-de-sac, which are designed for the automobile, are poorly adapted to the pedestrian. Their discontinuity inhibits pedestrian access to facilities and amenities, while their curvilinearity lengthens and confuses walking trips.

In contrast, the traditional grid patterns that predate the automobile were designed for the pedestrian but have required major adaptations such as one-way streets and traffic lights in order to achieve good automobile traffic flow. Without such adaptations to the grid, congestion is inevitable. On the other hand, when congestion occurs on arterial roads in a conventional suburb, it is generally caused not by the street network but by the segregation and concentration of single land uses such as regional shopping malls or office parks. The grid is a more inefficient and hazardous carrier of vehicular traffic. At each grid corner there are 16 possible intersecting paths for which priority has to be deciphered by the driver (or controlled by traffic lights). By comparison, T-intersections, common in conventional subdivision plans, have only 3 intersecting paths, where priority is easily grasped. In addition, the frequent grid intersections undermine the car's main advantage over other modes--rapidity of travel. Thus the grid compromises either speed or safety or both and, at high traffic volumes, even with traffic lights and stop signs, the grid creates gridlock. New urbanists argue in defense of the grid that conventional suburban layouts encourage car use. A recent study found that car ownership rates, household size and house location have a far greater influence on car use than street pattern type, which ranked ninth in influence.

Street Quality. The perceived quality of a street depends on both physical and operational attributes, some of which are incidental and some of which are designed. Street life, visual interest, social status and population density are incidental attributes dependent on culture and

history. On the other hand, some qualities such as safety, security and comfort are a function of design. Physical attributes, whether designed or incidental, may also be reinforced—or undermined—by operational attributes such as the level of maintenance and cleanliness. Taken as a whole, these attributes can produce a memorable image and a pleasurable feeling in the user, expressed as sociability, walkability, and delight to the pedestrian, and driving ease and safety to the driver.

The *sociability* of a street is critical to its perceived quality. Informal contacts that develop into social networks are at the root of feelings of belonging and security, which are prime factors in resident satisfaction. Street activity cannot be designed but it can be encouraged--or inhibited--by certain street characteristics. The most negative influence on sociability is heavy car traffic. To the extent that a street design encourages speed (as in wide through-streets) it will invite more traffic. To enhance sociability, particularly with regard to children's safety and play, most traffic experts recommend discontinuous street patterns of the kind found in conventional loop and cul-de-sac suburbs. Such street patterns consistently show a lower rate of accidents and a higher level of perceived security.

Satisfaction surveys of suburban residents often mention *walkability*. Walkability implies comfortable access to amenities such as schools, recreation, retail, and workplaces. The presence of these amenities can be affected by a street pattern but clearly not determined by it alone. However, in many conventional suburbs discontinuous, indirect, and confusing street patterns of loops and cul-de-sacs compromise accessibility. In addition, collector and arterial streets are inhospitable and unsafe because of high traffic volume, discouraging pedestrian use. Recent New Urbanism-type subdivisions that have adopted the grid pattern, create clearer and more direct pedestrian routes. Yet the amenities in these communities are generally beyond the five-minute walking distance desired by today's consumers. Walkability demands both a conducive street pattern and, equally important, a land-use arrangement that makes amenities accessible to pedestrians.

Viewing nature, whether it is in the form of parks, boulevards, or treed avenues in an urban environment is a source of *delight*. Green space has been found to have social and psychological benefits that explain the strong consumer preference homes facing parks, lakes and so on. Well-designed green space provides visual relief and opportunity for relaxation, becomes a place for casual contacts, and forms a haven for kid's play. Green space also has environmental benefits: it cools the air, recycles carbon dioxide, and retains rainwater. It is important to note that quality open space has been shown to make increased residential density more acceptable to residents. One of the most successful examples of open space use in an urban plan remains the eighteenth-century plan of Savannah, Georgia. Savannah's public open space is accessible and peaceful. Its thoughtful distribution delivers its benefit to the largest possible number of city dwellers. The city plan is organized in repeatable 675 foot-square "wards," each with a square in the center.

A city dweller behind the wheel expects as much pleasure out of driving as out of walking. Narrow, twisted and crowded streets may please pedestrians, but they frustrate drivers. To be enjoyable, driving requires unimpeded flow, perceived safety, and rich visual experiences on a large scale. These qualities are generally achieved by reducing and simplifying

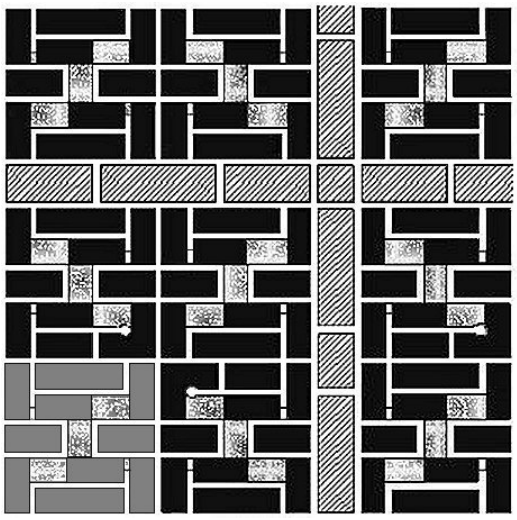
intersections, increasing lane widths, lengthening straight stretches, dividing traffic lanes, widening curves, and completely separating opposing streams of traffic by man-made or natural dividers. Treed boulevards acquire some of these qualities but the road that encapsulates all these positive attributes best is the urban parkway.

THE BEST OF BOTH WORLDS

For users, each of the two predominant suburban street pattern alternatives--loop and cul-de-sac, and grid--has distinct advantages. Discontinuous streets with loops and cul-de-sacs provide safety, sociability and transportation and land-development efficiency; continuous grid patterns provide connectivity and easy orientation. The two patterns can be combined to create a street layout that provides all of these attributes, while minimizing their respective disadvantages. The principle design goals of this new combined street layout is to prevent nonresident through traffic, to maximize the number of houses on cul-de-sacs and loops, to situate open space for maximum accessibility, and to accommodate a range of housing types. To achieve these goals, the alternative approach would have the following characteristics: orthogonal geometry for clarity of organization and directness of pedestrian access; loops and cul-de-sacs for local streets for safety, tranquillity, sociability and land-use efficiency; open space as a structuring and connecting element of the layout as well as for environmental and social benefits; a road hierarchy of local, collector and arterial, for distributing and moving car traffic effectively; and arterial roads that function not merely as traffic conveyors but as activity generators as well.

Figure 2. The building block of residential districts is a 40-acre (16Ha) block (bottom left of drawing).

The fundamental building block of this alternative approach is the residential quadrant (Fig. 2). It is roughly ¼ mile square (40 acres) and can be crossed on foot in five minutes. The quadrant is bounded by two collector streets and two arterial streets. Within the quadrant, residential streets are laid out in a modified grid so that cars cannot cross the quadrant, eliminating non-residential traffic. The use of looped, narrow streets reduces the speed and volume of vehicular traffic. Highest density would be at the edge of the quadrant adjacent to



the arterial streets, intermediate density adjacent to the collector streets, and moderate densities in the center. A continuous pedestrian footpath system provides residents with several direct route options to, public transit, retail, recreation and services. Connections made

on foot are established by way of an extensive and accessible network of open space and parks. By exchanging street space for open space the degree of connectivity is enhanced, walking is made visually rewarding and developable land increases.

CONCLUSIONS

The study summarized here draws lessons from recent and past subdivision street pattern designs. It examines how well they function, fulfill residents' needs and expectations, and address environmental concerns. In developing an alternative pattern that integrates the most important and desirable attributes of each approach, the study concludes: first, that it is possible to maintain the efficiency and quality of the conventional suburb while adopting the geometry of the grid; and second, that it is feasible and desirable to combine the tradition of the main street and the convenience of the commercial strip in a zone of mixed land uses that both relies on and supports transportation. By fusing the street patterns of conventional suburbs with those of the traditional grid-based city, and by recasting the arterial street in the role of activity generator, it is possible to create communities that are efficient, viable, livable, healthy and highly marketable.

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Comprehensive LCA reveals new critical aspects in offices

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1 INTRODUCTION

In recent years, there has been a tendency in Finland to assess that energy use (heat & electricity) is the most important aspect causing environmental impacts during the life cycle of a building (Aittola et al. 2000, Hara-Lindström 2001, Saari 2000). In the leading professional newspapers the use of energy is often presented to account roughly for 80-90% of the environmental impacts of a new building (Mölsä 2002, Siren 2001). Similar kind of results have been reported in many cases from other countries, as well (Anderson et al 2000, Thormark 2000).

We would, however, suggest that this is not necessarily the case. Many of the previous studies suffer from some limitations, such as a lack of life-cycle phases, comprehensive material inputs or extensive environmental data. Also, the range of environmental impacts has sometimes been interpreted quite narrowly.

There are already some observations in the academic papers, which support the view that other aspects may have a bigger importance to the life-cycle characteristics of a building than normally anticipated. For example, Norris et al. (2000) reports that some less massive material inputs, such as electrical, HVAC and interior finishes may be significant. Also Trusty & Meil (2000) point out the importance of building structures and materials in the environmental calculations.

The purpose of this study is to examine how significant the use of energy is in causing environmental impacts to a new office building during its life cycle. Based on preliminary studies, we made a hypothesis that the inclusion of lesser material inflows and life-cycle phases and the use of current and extensive data would decrease the importance of the energy service.

2 METHOD

A LCA (life-cycle assessment) was conducted to a new office building in Helsinki, Finland. Fifty years of use was chosen to be the basic life cycle of the building. The LCA consisted of inventory analyses, impact assessment and normalization as a part of interpretation.

The environmental impacts included in the calculation were those identified by the Ministry of the Environment as the most important in Finland (Rosenström & Palosaari 2000). The studied impacts were: climate change, acidification, eutrophication and dispersal of harmful substances, which included VOCs (Volatile Organic Compounds) and heavy metals. From the original list, the ozone layer depletion and biodiversity category were left out because of the lack of the accurate LCA data.

The LCA included all the major life-cycle phases of an office building: building parts and elements, site works, energy, water and cleaning service, maintenance, and demolishing. All the inflows included transportation and as much upstream information as possible. Particular attention was paid to the material-flows so that the less massive flows were also taken into account.

The data used in the LCA calculation were mainly collected from actual producers in Finland, and the age of data was typically less than 3 years. The benefits gained by combined heat and power (CHP) production used in Finland were allocated equally to the heat and electric energy. The quality of data was evaluated with six-dimensional estimation framework recommended by "Nordic Guidelines on Life-Cycle Assessment" (Lindfors et al. 1995). The overall quality of data was considered good (Table1).

Table 1. The quality estimation of the data used in the LCA.

Data Quality Table	Technological correlation	Geographical correlation	Representa-tiveness	Data Age	Acquisition method	Independence of data supplier
Average	1,8	2,3	1,9	1,3	2,0	2,1
Weighted average (by influence to environmental impact)	1,4	1,8	1,9	1,1	2,0	2,0
Maximum quality	1	1	1	1	1	1
Minimum quality	5	5	5	5	5	5

After the life-cycle inventory of the building, an impact assessment was conducted and the environmental impacts of energy service were compared against the impacts of the other life-cycle phases in every impact category. Finally, the impacts were normalized with the total emissions in Finland (Syke 2001). The normalized results were used to interpret the significance of different life-cycle phases.

3 RESULTS

3.1 Presentation of the case

A new office building, constructed in Ruoholahti, Helsinki, was selected as the object of the study. The building is designed for high-tech companies, and it is called HTC Porkkalantalo. It is owned by a Finnish real-estate company, Kapiteeli. Kapiteeli also has partly financed the LCA assessment. The HTC Porkkalantalo consists of three 5-floor office towers and has an estimated energy consumption of 166 kWh per year, which is typical to a modern office building in Finland but 40 % below the average (Motiva 2001). The main building parameters are given in Table 2.

Table 2. The building parameters of HTC Porkkalantalo.

Building parameters	
Name	HTC Porkkalantalo, offices A1, A2 and A3
Location	Helsinki, Finland
Gross floor area	15 586 m2
Operating time	75 hours/week
Structure	3 tower, post-tensioned, cast-in-place concrete
Envelope	
-exterior cladding	brick and curtain wall combination
-fenestration	low energy windows (U-value 0.8-1.0)
Operating energy	
-heat	72 kWh/m2
-electricity	94 kWh/m2

3.2 Impact assessment

The results of the impact assessment are presented in Table 3. The energy service accounts for roughly three-fourths of the climate change and acidification emissions. From euthrophication, waste water (included in other service) produces over 50 percent. The building materials (building parts & elements, and maintenance) are the most significant producer of VOCs and heavy metals.

Table 3. The environmental impacts of the HTC office.

Office building HTC	Climate change ton CO2-ekv	%	Acidification kg SO2-ekv	%	Eutrophication kg PO4-ekv	%	VOCs kg H2C4-ekv	%	Heavy metals kg Pb-ekv	%
Energy service	**32 000**	74 %	**96 000**	72 %	**8 000**	31 %	**1 200**	7 %	**10**	40 %
electricity	17 900		61 000		5 190		509		8,43	
heat	13 900		34 700		3 220		706		1,35	
Other life cycle phases	**11 000**	26 %	**38 000**	28 %	**18 000**	69 %	**16 800**	93 %	**15**	60 %
building parts & elem.	4 790		18 900		1 870		8 270		11,70	
site works	725		3 700		682		587		0,25	
other services	3 100		5 400		14 600		2 030		0,01	
maintenance	1 540		7 750		733		5 920		2,99	
demolition	533		2 270		264		41		0,21	
Tot	**43 000**	100 %	**134 000**	100 %	**26 000**	100 %	**18 000**	100 %	**25**	100 %

In Figure 1, the energy service of the HTC office is compared to the other life-cycle phases of the building. It can clearly be seen, that the energy service has a dominant proportion only in two of the five impact categories and in the rest of the categories it has a minor importance.

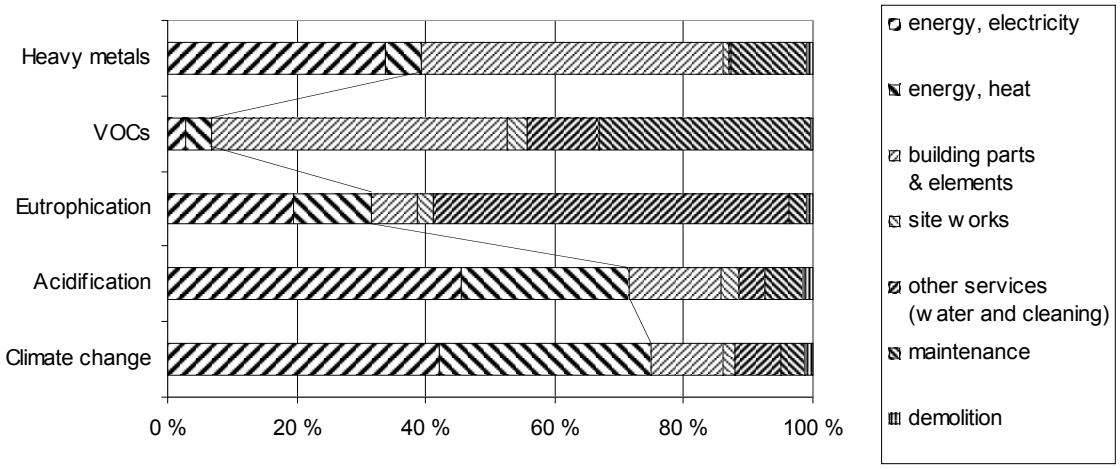

Figure 1. The proportions of different life-cycle phases of the HTC office in the studied impact categories.

3.3 Normalization

Normalization is a voluntary part of the LCA, but it was conducted here to help interpretation of the result. In normalization, all the environmental impacts were weighted against the overall environmental impacts in Finland.

From the normalized result, presented in Figure 2, we can see that the life cycle of an office building equals to 0,02-0,06 % of the annual environmental impacts in Finland. The climate change has the highest value and heavy metals the lowest. When we count the normalized results together, we can see that the energy service and other life-cycle phases have approximately equally large proportions of the environmental impacts.

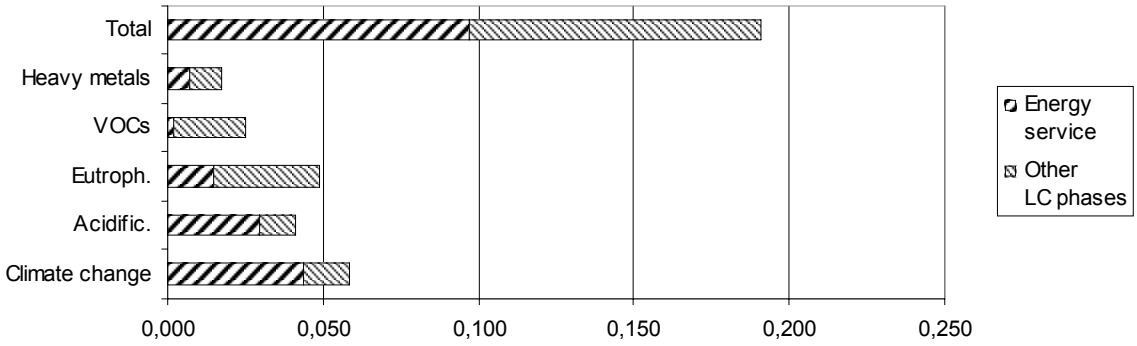

Figure 2. The normalized environmental impacts caused by the HTC office.

4 DISCUSSIONS AND CRITICAL REVIEW

As could be seen in the previous chapters, the energy service may have a smaller proportion of the environmental impacts in an office life cycle than generally expected. In this chapter, we try to bring forward some of the reasons that may be the cause of the difference.

No single contributor could be found to be the cause of the difference, but three smaller ones are presented here. Firstly, the lesser life-cycle phases: maintenance, site works and other services, all contribute relatively much to the overall environmental impact of the office. Especially in VOC and eutrophication categories, they have a considerable effect on the result, as could already be seen earlier in Figure 1.

The use of current and extensive data is another issue affecting the result. In Figure 3, we can see the LCA results of three similar office buildings calculated at Jaakko Pöyry in 1998 and 2001. During that time, the company has changed from a general database to a producer-based, more extensive database. In the first three impact categories: climate change, acidification and eutrophication, the calculated impacts are roughly at the same level and the difference is mainly due to the differences in constructions. In the last two, less often calculated categories; there is a significant difference between the results. The use of current, producer-based data has a clear influence on the results in those categories.

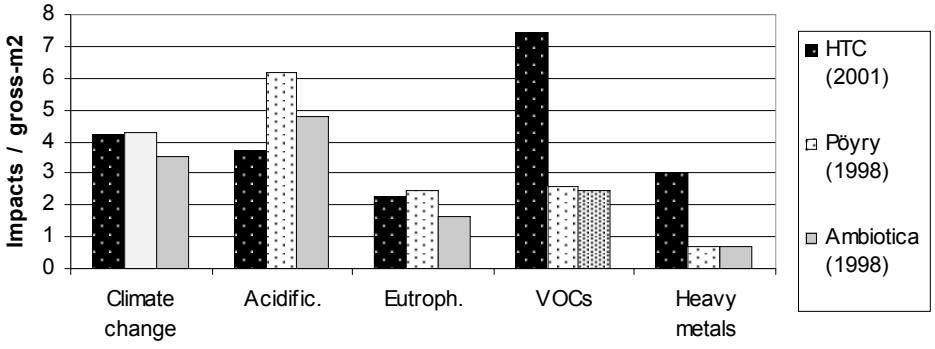

Figure 3. Comparison of the environmental impacts of the building materials used in three similar office buildings with different quality of LCA data.

A third aspect affecting the LCA results is the cut-off criteria used in LCI (life-cycle inventory) phase. In Figure 4, we can see that the less massive material inputs have a clearly more significant contribution to some environmental impacts than to the others. With the

typical 5% cut-off criteria roughly the half of the VOC and heavy metals emissions would have been left out from the calculations.

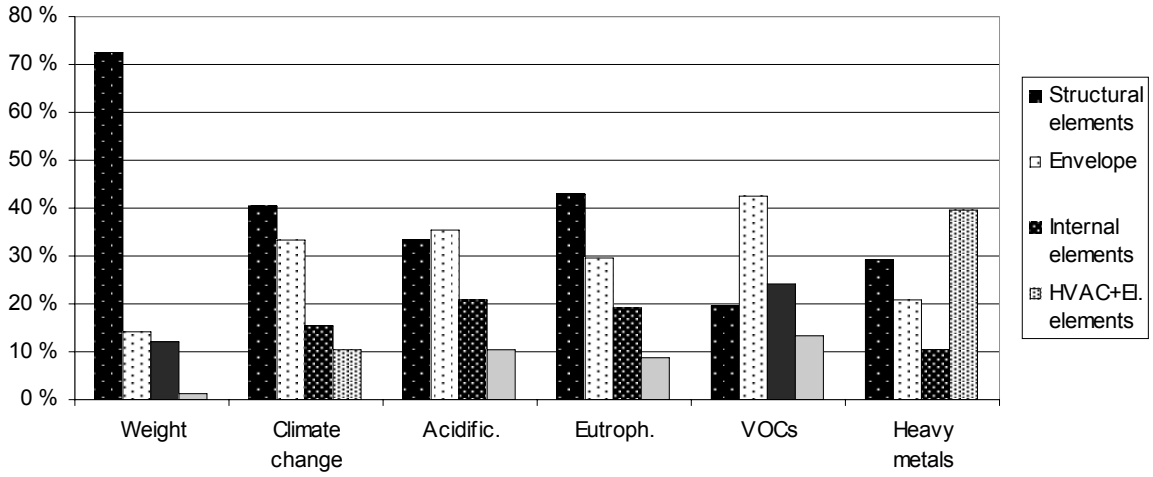

Figure 4. The contribution of lesser mass inputs in different impact categories to the LCA results of the HTC office.

We have conducted a LCA of one office with three individual towers in this study. One case is clearly not enough to make generalizations about the environmental impacts during the life-cycle of a new office. This case could only indicate that the lesser inflows might have a stronger influence on the environmental impact of an office than generally expected. In addition, although the importance of energy service may be smaller than commonly considered, it does not alter the fact that it still is one of the most significant inputs in the system and often the easiest one to compete.

Some life-cycle phases that have a quite significant role in the study, such as the use of electricity and waste water, are strongly dependent on the behaviour of the organization using the building. It is questionable to some extent, whether these inputs should fully be included in the LCA of a new building. The effects of electricity and waste water inflows are especially notable in eutrophication category, but are also relevant in other categories.

5 CONCLUSIONS

The most significant finding of the study was that only in minor part of the environmental impact categories, namely in climate change and acidification, the energy service was found to be the most important part of the life cycle of the new office building HTC. The energy service produced 72-74 % of those impacts.

In other impact categories (VOCs, heavy metals and eutrophication), the energy service caused only the minor part (10-40%) of the impacts. The most important contributors in those categories were the building materials and water service. Additionally, when the results were normalized against the yearly emissions in Finland, the average significance of the energy service was close to 50 %, which is clearly below the figures (80-90%) often presented in professional papers in Finland.

The study indicated that the contribution of energy service may be considerably less to the life cycle of a new office building than typically anticipated. If that also is the case at the more

general level, it should be taken into consideration when aiming at having offices with less environmental impacts.

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HQE²R – Sustainable Renovation of Buildings for Sustainable Neighbourhoods

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INTRODUCTION

The Institute of Ecological and Regional Development is the German contractor of "Sustainable Renovation of Buildings for Sustainable Neighbourhoods" (HQE²R – Haute Qualité Environnementale et Economique Réhabilitation), funded by the EC under the Fifth Framework Programme. The project started in September 2001 and will continue until August 2003. Co-ordinated by CSTB France (Centre Scientifique et Technique du Bâtiment) it combines research and demonstration aspects by co-operation of 10 European partners in connection with 15 municipal case studies.

The project's objective is to develop a new methodology and the necessary tools to promote sustainable development and quality of life on the crucial and likewise challenging level of urban neighbourhoods. HQE²R will be a decision support tool for municipalities and their local partners, focussing on the aims of inhabitants and users of neighbourhoods. In its integrated approach it is meant to be a framework generally applicable in Europe. The project is using the case studies as model neighbourhoods for the methodology to be provided.

This paper presents the basic cornerstones of the global HQE²R methodology. The works that are basic to this paper are the result of teamwork within HQE²R (see references). Nevertheless the author remains responsible for the contents and correctness of this paper.

THE NEIGHBOURHOOD AND SUSTAINABLE DEVELOPMENT OBJECTIVES

The neighbourhood as the object of research and (proposals for) development action is not only relevant because it represents an effective scale of intervention for dealing with certain ecological or social problems or for implementing a participative approach. Apart from this, it is a real-life terrain – frequented daily, committed or not, but never neutral. And even if neighbourhood life no longer characterises urban life, it still hasn't disappeared and might even benefit from a revival. Nevertheless it is quite difficult to agree on a common definition of what is a neighbourhood especially within an international project. So the first steps within HQE²R were about clarifying the neighbourhood and sustainability-approach.

The Neighbourhood

The neighbourhood can be seen in as many ways as activity fields do exist for the subject, starting from sociology, via urban- and regional planning and architecture to economy. To make it even more difficult, what is regarded a neighbourhood may also differ with the different actors / users involved.

Therefore HQE²R started with the definition of a common subject of research. In a first instance this was defined very formal and physical: Subject of HQE²R first of all is a cluster

or ensemble of buildings / built urban environment with a need for renovation towards *sustainability of the built environment*. This may be an urban (residential) area framed by large roads or other (linear) structures or a more or less homogenous ensemble of similar types of buildings etc. ("urban structural types") and might be chosen quite liberally. Once having identified these clusters – roughly predefined by our case-study-areas and structured along spatial elements (see below) – we will in a second step look a little closer how far these "micro-urban territories" are congruent with different possible notions of neighbourhood (social, economic, administrative, related to user groups etc.) or to what extend we have to widen (or sharpen) the scope of investigation as far as the *sustainability of neighbourhood(s)* is concerned. Thereby we should especially take into account the perception of "neighbourhood" as represented by different user groups / stakeholders within these areas. This means the "neighbourhood" may reach beyond our physical subject or our physical subject may encompass more than one neighbourhood.

Following this approach of explication rather than definition, HQE²R does not necessarily demand a common understanding of the notion of neighbourhood. Nevertheless HQE²R comes with an underlying consensus, that the identity of a neighbourhood has more to do with a sociological context than a purely geographic or administrative definition. Starting from this, we can retain several features which will have great importance in defining neighbourhoods (Charlot-Valdieu et al., 2002a). Each of these issues contributes to the identification, explanation and role of a neighbourhood within the urban context:

- The inhabitants having a sense of community, or belonging to the community, derived from local centres, services and a sense of place or specific symbolic elements, neighbourhood life, the collective management of public property.
- Urban consciousness, social and political participation, founding history of the neighbourhood.
- Economic characteristics.
- The area's functions and role in the city.
- Physical cohesion created by the dominant architectural style and the arrangement of public space.
- Urban morphology as well as its topography and natural aspects.

As already introduced above these last two points describe the physically or rather spatially defined starting point when approaching a neighbourhood – at that time merely a "micro-urban territory": Since HQE²R has "renovation" in its core and "renovation" in its core is directed towards the built environment, the elements for analysis are represented by different built and non-built structures. Therefore the following four categories, together with the sustainable development objectives (see below) define the framework for analysis and further work:

Residential space. The habitat always lies at the centre of urban refurbishment policies and the forms and styles of housing/dwelling are often decisive in characterising the neighbourhoods and predetermining its development. This element includes the whole volume occupied by the residential space including gardens and private spaces around housings.

Non – Residential space. This element includes both: Buildings and spaces hosting *facilities and services* and a*ctivities in the industrial and tertiary sectors* which are present in the neighbourhood. Facilities and services contribute towards the social link by providing also the flows of information needed by the neighbourhoods' inhabitants. Public, social, and cultural

services will be included in this category, together with public amenities. Private services to the individual (human services) should also be included in this category where they fulfil a "proximity" function.

Activities in the industrial and tertiary sectors bear witness to the economic, industrial or commercial vocation of the neighbourhood. They may form the structuring backbone, as was the case in the past for the textile or mining industries. The activities may also form poles of attraction for the city or conurbation (cultural, sporting, economic etc...).

For these two categories - facilities and services on one hand and activities on the other - the dividing line is that of spatial relevance. In the first category, we find close-to-hand amenities and activities, mainly (but not exclusively) to meet the local needs of the neighbourhood inhabitants whereas, in the second category, we find amenities or activities physically present in the neighbourhood but the purpose of which is to meet the requirements or operate with populations coming from the entire city or conurbation or from even greater distances.

Non-Built space. This element includes all the parts of the neighbourhood which are not built even if they are not really natural. They are the green spaces, the woods and all the natural areas. These spaces are distinguished from the housings and from private green space surroundings (see above). In fact, they are mainly public open spaces.

Infrastructure. It includes all the technical infrastructure present in the neighbourhood: roads, streets, pavements and networks (electricity, gas, water, district heating, communication, …)

These four elements constitute the physical superstructures of the neighbourhood which must be used by the inhabitants and the users. In addition to its basically physical character therefore these elements are represented also at a more social scale: The uses of the structures. In consequence within the HQE²R-methodology each element will be studied at these two scales: The structures and the uses (Table 1).

Table 1.: Neighbourhood-elements by structure and use (Charlot-Valdieu et al., 2002a)

Neighbourhood Element	**Structure**	**Use**
Residential Space	housing stock, envelope and equipment quality,…	inhabitants distribution by status, age, profession; energy consumption, …
Non – Residential Space	building stock, envelope and equipment quality,…	type of uses, users coming from inside the neighbourhood or not, …
Non – Built Space	green spaces surfaces and quality,	use of green spaces, cleanliness, safety,…
Infrastructure	roads length, networks quality, public transport supply,…	Mobility of inhabitants, inter-modal distribution, energy, water and material flows,…

Sustainable Development Objectives

To apply a procedure for sustainable neighbourhood development, it is necessary to define sustainable development objectives for the neighbourhood. These local objectives must

finally be set by the local community, in accordance with joint consultation procedures that will have to be defined. As a starting point for this process within HQE²R a common set of sustainable development principles and objectives was defined on a general basis, which have to be specifically adapted to the territorial scale of the neighbourhood.

Resting on a general concept of sustainable development with the idea of a triple dividend – economic efficiency, social solidarity and environmental caution – in its core, the following guiding principles of sustainable development were identified:

- Thinking global: Territorial approaches can only be sustainable when they are accompanied by an analysis of the territory in terms of its local (neighbourhood, city) and global (agglomeration, region, country, planet) environment.
- Taking long-term-developments into consideration as well as its relation with the present (conceiving future changes and possible reversibility / adaptability.
- Participation of the population in the decision making process.
- Principles of precaution and prevention, integration and solidarity.

With regard to these principles, five (A to E) overall objectives are proposed for building and neighbourhood development towards sustainability: A - to improve Diversity, B - to improve Integration, C - to preserve and valorise Heritage (natural and cultural), D – to improve Quality of Life, E - to reinforce Social Link

Together with the general elements of a neighbourhood these 5 overall objectives (and 21 more detailed general targets below them) build the basic framework for the analysis and development toolbox for neighbourhoods to be elaborated within HQE²R. Resting on this framework a global methodology was developed that will serve as a common core for analysis, diagnosis and action planning towards sustainability within the HQE²R-case-study-areas. It is at the same time the starting point and nucleus for the further development of the final HQE²R-methodology.

THE HQE²R GLOBAL METHODOLOGY

Sustainable development must lead to a "policy and strategy aiming at continuing development in time of economic and social development, whilst complying with the environment and without jeopardising the natural resources that are indispensable to human activity" (European Commission, 1992). It must also reside on true governance, defined as an overall approach to the participation of inhabitants, users and socio-economic players of the neighbourhood in expressing the problem, defining the objectives of a project and defining the strategy including the means assigned, in implementing, monitoring and evaluating the project. These principles also lie at the heart of Local Agenda 21 processes and in fact the starting point for sustainable neighbourhood development might be described as entering an LA21 process on the neighbourhood scale, ideally embedded into an urban LA21 process.

In general HQE²R will be a strong decision aid tool for municipalities and their local partners (such as public administration, social owners, city planners, residents, local economy…) which will direct them towards sustainable reconstruction of their cities and improved quality of life. In its core it is to assess different development paths for neighbourhoods (scenarios) against defined sustainable development targets. Thereby the term assessment encompasses the three stages *inventory, diagnosis* and *evaluation*. A crucial principle of the approach is participation of all involved or concerned parties from the beginning. This participation will encompass different forms from information (to give the information to the population) via

consultation (to ask for comments of the population), dialogue (to take into account advice of the population) up to co-operation (to decide and possibly act in a common process).
The process starts with an *inventory*, that analyses the starting situation with a wide scope. This inventory must concern both all the fields of sustainable development (economy, social and environment) and bring up items of information applicable to each of the global sustainable development objectives.

Thereby the scope is defined by crossing the sustainable development objectives (and targets with the neighbourhood elements. This cross-coverage leads to the drawing up of an analytical grid consisting of 20 major fields, as shown in table 2.

Table 2: The analytical grid for the built environment and neighbourhood: Sustainable development objectives by spatial neighbourhood-elements

	Residential Space	***Non – Residential Space***	***Non – Built Space***	***Infrastructure***
Improve Diversity				
Improve Integration				
Preserve and valorise Heritage				
Improve Quality of Life				
Reinforce Social Link				

20 analytical fields as a shared guiding framework and basis of the specific works in the case-study-areas.

The analytical grid comes into action first within the inventory of the case-study-areas. For each of the 20 fields an inventory checklist is prepared to set up a framework guiding the works in the case-study areas. The checklists provide an explanation of the understanding of the sustainable development objective for the specific field and a set of suggested questions to be answered and information to be collected during inventory and diagnosis. Furthermore a set of indisputable core-indicators was designed as a consensus on a minimum scope for assessment (Charlot-Valdieu et al., 2002b). The checklists at the moment have provisional character for the use in the case-study-areas. The results and experience of these demonstration works will be used to further develop and refine these pilot version into specific inventory sheets as a tool within the final HQE²R-methodology.

After finishing the inventory the definition of what is essential in the neighbourhood is achieved by establishing a *diagnosis*. The objective of the diagnosis is to highlight the situation of the neighbourhood for optimal definition of the strategies or plans of action towards sustainable development. It is not a matter of evaluating public policies as a whole (municipal policies and those of the partners involved) but of proposing scenarios on how the neighbourhood might develop towards the five global objectives of sustainable development as well as the 21 targets. By definition, this is a cross-cutting approach, encompassing all sectors and services of the city.

The diagnosis in a first step as a result of a *"preliminary assessment"* ensures the identification of issues (energy consumption, healthy housing, social services, networks, local economic development ...) meaningful for the further development of the neighbourhood. It presents the strong and weak points and will be the basis to derive, to justify and to argue the proposals for actions or solutions with respect to the situation defined in the inventory.

On completion of the phase of diagnosis the local objectives of sustainable development are determined by defining the *stakes* for sustainable development of the neighbourhood. This is done at a given moment with regards to the positions and interests of the different local stakeholders (inhabitants, local elected officials, municipal services, consultants, entrepreneurs ...) but cross-checking the global sustainability targets. Defining the stakes first of all is understood as a means to organise the identified development issues and problems into a *hierarchy of action* in terms of such to be tackled at short, medium and long term. For this "ex-ante evaluation" on the basis of development scenarios it might in a second step be necessary to analyse defined crucial issues in greater detail with the help of specific tools – *"decision support"*. For this purpose HQE²R comprises also a comprehensive documentation and discussion of tools and methods for the assessment (inventory, diagnosis and evaluation) of the built environment towards sustainability existing in the partner countries (Antonini et al. 2002) and will furthermore as a final result suggest approaches specifically adapted for the use on the neighbourhood scale.

The last phase within HQE²R comprises the choice of sustainable development indicators for *evaluation*. This choice has to reflect the neighbourhood's specific sustainable development issues and objectives but is supported by the set of pre-defined ("indisputable") core indicators (Charlot-Valdieu et al, 2002b). According to the local situation the evaluation might furthermore be designed as the starting point of a long term monitoring.

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The Search for the Most Eco-Efficient Strategies for Sustainable Housing Construction

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1. INTRODUCTION

In recent years, a growing number of sustainable building projects has been realised. More and more, sustainable building becomes part of daily building practice. However, until now, (Dutch) sustainable building is predominantly based on a more or less intuitive approach without knowing the exact consequences for reduction of the environmental impacts. For example, in recent years some national packages of sustainable measures has been developed in the Netherlands, including a package for new construction of houses (SBR, 1996). In these packages options are given to bring sustainability into building practice. It has led to a broad application of sustainability principles. Nevertheless, it gains no insight in the magnitude of the environmental benefits. Therefore, optimal choices related environmental ambition levels are still difficult to be made. To give direction to this kind of choices, working with strategies to increase the environmental performance offers good opportunities. This paper aims to determine the potential environmental benefits of these strategies. The first results of calculations are presented. The focus is on houses. In the end, the research seeks for the most eco-efficient strategies for sustainable housing construction. The paper is based on a study, which is part of the research project Sustainable Construction and Renovation of Houses within the Delft Interdepartmental Research Centre 'The Ecological City' at Delft University of Technology. This research centre carries out pioneering and innovative research for a sustainable and liveable built environment.

This paper addresses the following questions.

- Which approach is followed to gain insight in the magnitude of environmental benefits of options for sustainable construction?
- Which strategies can be distinguished to improve the environmental performance of houses?
- What are the environmental benefits of these strategies?
- Which strategies offer good perspectives for sustainable housing construction?
- Which bottlenecks have to be solved to make other strategies more promising?

In the second section the research design is discussed. Strategies are chosen as an approach to steer the numerous options for sustainable construction. The environmental benefits of the strategies are discussed in the third section. Subsequently, the fourth section presents the conclusions. References are listed in the fifth section.

2. RESEARCH DESIGN

Figure 1 shows the research design of this study. Priorities, strategies and the environmental assessment tool are described in three successive sections.

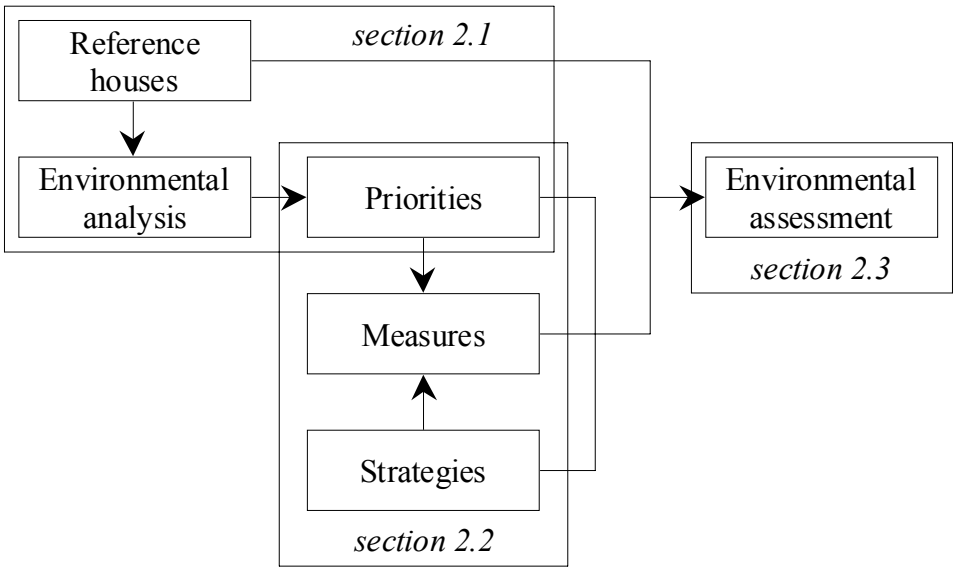

Figure 1 Research design

2.1 Priorities

A house consists of innumerable components and materials, which are not of great importance regarding the environmental impacts. Hence, the study started with the appointment of priorities for reduction of the environmental burden of houses. Material use, energy consumption and water consumption throughout the entire life cycle of the houses were taken into account. Major contributors to the environmental impacts were identified on the basis of environmental analysis of three reference houses: a terraced house, a semi-detached house and a gallery flat. These houses are a good reflection of traditional construction, as they represent a basic quality in construction and habitation (Novem, 1999a). The following findings result from this analysis (Klunder, 2001).

- Housing typology is not very relevant for identifying priorities for improvement of the environmental performance of houses.
- Priorities on material use relate mainly to components that involve large quantities of materials (for example foundation, floors and walls), but there are also some materials, which should be avoided regardless of quantity (including lead, copper and bitumen).
- Priorities on energy consumption relate to all energy functions (space heating, hot tap water, lighting, ventilation and auxiliary energy) belong to the priorities, because not only the energy consumption, but also the energy carrier (electricity or gas) is of great interest in assessing the environmental impacts.
- No priorities relate to water consumption, because the environmental impacts of water consumption are as good as negligible, compared to the environmental impacts of material use and energy consumption.

2.2 Strategies

To be able to answer questions such as ‘does the use of renewable energy or recycling and reuse lead to the largest environmental benefits?’ or ‘how important is the choice of materials for the environmental performance related to all other sustainable measures?’, strategies instead of measures for sustainable construction are applied as unit of environmental analysis. Four strategies are concerned with materials and another three strategies involve energy.

Sustainable material use is associated with integral chain management. Four strategies can be distinguished to meet this principle (Blaauw, 2001):

1. dematerialization (M1);
2. material substitution (M2);
3. extension of service lives (M3);
4. improvement of reusability (M4).

Dematerialization refers to minimisation of the size of the flow of materials in the building industry. Material substitution is directed towards reduction of the environmental impacts per unit of material through the entire service life. Next, as a consequence of extension of service lives the environmental impacts per functional unit decreases, because the environmental impacts are spread over a longer period. Improvement of reusability supports the use of building components and materials in a subsequent life cycle instead of dump or combustion.

Regarding sustainable energy consumption minimisation of fossil fuels is of major importance. The *trias energetica* presents three steps to come to that (Novem, 1999b):
1. reduction of energy losses (E1);
2. use of renewable energy (E2);
3. use of efficient techniques (E3).

Reduction of energy losses comprehends measures, which contribute to a low energy need. Renewable energy in housing notably means solar energy and warmth from soil, water and air. Finally, use of efficient techniques implies supply of the remaining energy need with an efficiency as high as possible.

2.3 Environmental assessment tool

Both priorities and strategies, combined with an inventory of actual technological developments, led to the composition of sets of measures from the national packages for sustainable building (see introduction), which were environmentally assessed. From international projects, for example, within the International Energy Agency (Knapen and Boonstra, 1999) and the Green Building Challenge (Cole and Larsson, 2000), it appears that the Netherlands goes ahead concerning the development of tools for environmental assessment of buildings. Therefore, the Dutch tool Eco-Quantum was used to make the calculations presented in this paper (Mak et al., 1999). The earlier mentioned reference houses were applied as a reference point for determining the environmental benefits of the strategies for sustainable construction. No weighing was applied in the assessments, so all environmental impacts were considered as equally important.

Eco-Quantum has the following features.
- It is a tool for environmental impact assessment of houses, meant for architects, clients and municipal councils who can use it for, amongst others, optimising designs, benchmarking and policy framing.
- It conducts an LCA of the flows of materials, energy and water in houses. The flow of materials regards the use of materials of all house components, including material-embodied energy. The flows of energy and water comprise energy consumption and water consumption respectively during the service life of the house.
- Twelve impact categories can be analysed with Eco-Quantum: depletion of raw materials, depletion of fuels, global warming, ozone depletion, photo-oxidant formation, human toxicity, ecological toxicity, acidification, eutrophication, energy consumption, non-hazardous waste and hazardous waste. The latter three are not really impact categories, but pressure indicators (MegaJoules and kilograms). Although such pressure indicators have a strongly recognisable function, this paper sets them aside to avoid double counting.

3. ENVIRONMENTAL BENEFITS OF STRATEGIES FOR SUSTAINABLE CONSTRUCTION

Section 3.1 presents the results of the environmental assessment of sets of measures per strategy for sustainable construction. Moreover, some housing concepts were calculated, which is discussed in section 3.2.

3.1 Materials and energy

The environmental benefits of the sets of measures per strategy are presented in Table 1. The first column contains the encoded strategies (see section 2.2), while the second column gives the accompanying set of measures. The next nine columns represent the environmental benefits per environmental impact. This is an average percentage of the three types of housing, because the differences between the environmental impacts of the various houses appear to be less important than the differences between the environmental impacts of the strategies for sustainable construction. Finally, the last column contains the average percentage of the nine environmental impacts. Percentages from 5% are considered as significant, so in all other cases no percentage is shown.

Table 1 Environmental benefits of strategies for sustainable construction in percentages

Strategy	*Set of measures*	*Environmental impacts*									
		M	*F*	*GWP*	*ODP*	*POCP*	*HC*	*EC*	*AP*	*NP*	*Average*
Materials											
M1	10% smaller dimension of load-bearing structure										
M2a	renewable materials: timber-frame construction			5	8				-5	-6	
M2b	plastics instead of lead and copper	54					14	47			13
M3a	90 years service life of house instead of 75 years	17	17	18	20	19	19	18	19	19	18
M3b	5 years extension of service life of components	8									
M4	reuse of foundation and interior wall	8		5		8	4		5	5	5
Energy											
E1	R_c=4.0 instead of 3.0 m^2K/W, U_{window}=1.2 instead of 1.7 W/m^2K		11	8							
E2	thermal and photo-voltaic solar-energy systems	-45	7	8	-20		-6		-7		-7
E3	low-temperature space heating and high-efficiency ventilation		5	5			6		6	5	

Explanation of abbreviations: M depletion of raw materials, F depletion of fuels, GWP global warming, ODP ozone depletion, POCP photo-oxidant formation, HC human toxicity, EC ecological toxicity, AP acidification, NP eutrophication.

The outcomes lead to the following findings.

- Dematerialisation does not result in a significant environmental benefit. Nevertheless, possible benefits are unambiguous, due to reduction of the amount of the same material.
- Regarding material subsitution an environmental benefit on the one environmental impact often goes together with an environmental disadvantage on the other environmental impact. Conversely, there are particular materials which cause a huge environmental burden, which can be reduced in a rather simple way.
- The substantial environmental benefits of extension of the service life of houses is a consequence of not needing a new house during the extended period. Extension of the service lives of both houses and house components always result in reduction of the environmental burden on all environmental impacts.

- Reuse brings about an improvement on six environmental impacts, but the average score only is significant with respect to the terraced house and the semi-detached house.
- Reduction of energy losses causes environmental benefits on energy consumption without worth mentioning environmental drawbacks on material use.
- Use of renewable energy leads to considerable environmental drawbacks, due to four environmental impacts, including depletion of raw materials. The environmental benefits are comparable to the environmental benefits of reduction of energy losses.
- Finally, use of efficient techniques results in smaller environmental benefits on depletion of fuels and global warming than the previous two strategies. To the contrary, environmental benefits on other environmental benefits are achieved.

3.2 Housing concepts

Housing concepts can be seen as a combination of strategies in a coherent way. Such concepts can yield larger profits than separate (sets of) measures, but (sets of) measures can also compete with each other. Therefore, some housing concepts were environmentally assessed with respect to the terraced house: an integral concept, a flexible concept and an energy concept. The integral concept reflects the possible environmental benefits by the current state of the art in technology. The flexible concept and the energy concept represent current popular solutions in sustainable building. Table 2 lists the sets of measures and environmental benefits as in Table 1.

Table 2 Environmental benefits of sustainable housing concepts in percentages

Concept	*Set of measures*	*Environmental impacts*									
		M	*F*	*GWP*	*ODP*	*POCP*	*HC*	*EC*	*AP*	*NP*	*Average*
Integral	see Table 1, except photo-voltaic solar-energy system	17	35	39	29	24	24	36	21	23	28
Flexible	house width 6.0 instead of 5.4 m, additional interior walls, service life load-bearing structure 150 instead of 75 years	-5	-9		11	7	-5	-6	-5	-4	
Energy	R_c=4.0 instead of 3.0 m^2K/W, Uwindow=1.2 instead of 1.7 W/m^2K, insulated door, heat pump, floor heating, solar-energy systems and high-efficiency ventilation	-105	43	34	-74	-21	-33	-19	-37	-17	-25

The findings are listed below.

- Application of all sets of measures in Table 1, joined in an integral concept, results in an average environmental benefit by 28%. Decrease of the environmental burden of material use equals decrease of the environmental burden of energy consumption. This implies that ambitions like ‘a factor of 20’, which means a twenty times higher environmental efficiency, is still far away.
- Flexibility and energy saving are commonly seen as promising ways to substantially reduce the environmental impacts of housing construction. However, the outcomes of calculations on the flexible concept and the energy concept show that this is contestable. The flexible concept does not lead to a worthwhile improvement of the environmental performance, while the energy concept even involves a considerable worsening of the environmental performance by 25%. Therefore, flexibility and energy saving may not be looked upon as indisputable solutions to achieve sustainable housing.

4. CONCLUSIONS

The following conclusions are drawn from this study, answering the questions posed in the introduction.

- Working with strategies seems to be a suitable approach to make optimal choices concerning measures for sustainable construction.
- Seven strategies can be distinguished to improve the environmental performance of houses: dematerialization, material substitution, extension of service lives and improvement reusability (related to material use) and reduction of energy losses, use of renewable energy and use of efficient techniques (related to energy consumption).
- The average environmental benefits of sets of measures belonging to these strategies amount to 13% for material substitution, 20% for extension of service lives, 5% for improvement of reusability and -7% for use of renewable energy.
- Dematerialization, reduction of energy losses and use of efficient techniques offer good perspectives for sustainable housing construction, because they yield positive consequences on all environmental impacts. Unfortunately, these consequences are marginal or restricted. The difficulty of material substitution is that substitutions alternately are favourable and unfavourable with respect to the environmental impacts.
- The huge environmental burden of the material use of installations has to be reduced to make use of renewable energy a more promising strategy. Furthermore, extension of service lives, flexibility and reuse seem necessary to make a leap forward in the environmental efficiency of houses. However, the ultimate environmental benefits have to be reached in the future, so these are associated with large uncertainties.

Two final remarks have to be made. First, the importance given to each environmental impact largely influences the ultimate choice of one or more strategies for sustainable construction. Second, further research should concentrate on other housing designs and construction techniques, both from the Netherlands and from abroad. Accordingly, this research has to be considered as start of the determination of the potential environmental benefits of eco-efficient strategies. The research will be continued in a PhD on optimisation of the environmental performance of houses.

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Statsbygg's method to implement the General Environmental Programme at Fornebu

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INTRODUCTION

When the new Oslo Airport at Gardermoen opened in 1998, the old airport at Fornebu in the municipality of Bærum, was closed down. The area of approximately 3,5 square kilometres, situated about 10 kilometres from the centre of Oslo, was decided to be developed as an urban area with a mix of commercial and industrial buildings and residences, and with a park in the middle. Within ten years this new city district will be represented by more than 6000 households and 25.000 places of work.

Before planning of the area started it was decided that a General Environmental Program for the Fornebu area should be developed– to ensure that the effects on natural resources, environment and the society would be properly assessed during the process.

The General Environmental Program for Fornebu was prepared in 1999 by the principal owners of the area, the Directorate of Public Construction and Property (Statsbygg) and Oslo Municipality. It was also approved by the municipality of Bærum and became a part of the master plan for Fornebu.

THE GENERAL ENVIRONMENTAL PROGRAM FOR FORNEBU (GEP)

The General Environmental Program for Fornebu (GEP) points out a set of objectives and efforts to bring the development into an environmentally sustainable direction. It also points out what could and should be done by those involved – the local municipality, the major landowners, the developers and future owners of the area, and the regional authorities. They are all responsible to contribute to realise the program.

The GEP focuses on five main issues – transport, energy, waste and the use of materials, the natural and cultural landscape and pollution:

Transport

Among the main objectives is to minimize the need for transport by motor vehicles, and to arrange so that public transport systems will be chosen by a major share of those living or working in the area.

To realise this objective an attractive public transport system must be developed, as well as an attractive, safe and well connected road system for bicycles and pedestrians.

Being able to offer local services, such as nursery schools, sport centres, post office and a variety of shops will also reduce the need for transport in and out of the area. The location of service centres and places of work should also be arranged to minimise the need for motorised transport, and the number of parking places .

Future employers are invited to reduce or adjust the supply of parking facilities as an effort to stimulate the use of bicycle or public transport.

Energy saving and use
The main objective related to this issue is to develop an energy supply system that minimises the use of energy and is flexible with regard to future energy sources. The system should also be based on renewable resources. To realise this the area must be arranged for heating from distant supply sources, including central heating plants.

Planners and future owners should also demand for energy-effective solutions in the planning and projecting of buildings. The local municipalities could also demand an energy-/effect budget to be enclosed by those applying for building licences.

The use and handling of materials, including the production of waste
The Environmental Program points out that environmentally friendly building materials should be chosen as far as economically viable in all building and construction work.

An other important environmental objective is to attain maximal re-use and recycling of local resources within the Fornebu area. During the demolition and construction there will be generated a big amount of by-products, such as asphalt, concrete, rock and soil. Re-use and recycling of these existing materials at Fornebu will reduce the need for transport in and out of the area, and in a wider sense conserve the virgin recourses of rock in the Oslo area.

Landscapes - natural and cultural
Natural landscape and cultural traces should be protected and preserved for the future.
As part of the development process there should be arranged for outdoor life, and recreational areas. It is also important to avoid conflict with the nearby environmental protection area which is an important nesting place for birds.

Pollution and noise
In addition to being the site of the old airport Fornebu has been the location of various activities throughout the years, such as engineering workshops. A current project is to clean up existing pollution in the ground. Great efforts will be effectuated to avoid the diffusion of hazardous wastes from old deposits and to secure the ground water, soil and sea against pollution from new sources.

THE METHOD FOR IMPLEMENTATION
All developers are obliged to integrate the GEP in their planning and construction of the Fornebu area. This means developing their own environmental plans, including a set of objectives and efforts to implement the GEP.

Few General Environmental Programs have been developed in Norway and there has been little experience in how to implement such programs. Being responsible for the construction of roads and technical infrastructure at Fornebu, Statsbygg's project Infrastruktur Fornebu (IFBU) is breaking the first ground. Consequently IFBU is one of the first to integrate the GEP into their work. In order to do this in a systematically way IFBU decided to develop their own method of implementation.

Integration into IFBU's quality system
To implement the GEP IFBU has developed an integrated environmental and quality management system. This system includes a set of objectives, plans, routines and processes to secure that environmental aspects are taken into account when preparing the tender documents.

Engaging a full-time environmental manager
IFBU has engaged a full time environmental manager who is responsible for the implementation process in the project. The manager's mandate is as follows:

- Advisory services on environmental issues in general
- Evaluation of current work regarding environmental performances
- Taking care that environmental plans are developed and implemented throughout the project
- Co-operation with project leaders, consultants and contractors.
- Being a guidance towards the completion and implementation of environmental plans and accounts
- Arranging environmental courses
- Initiating the development of new solutions to environmental problems.

Document Requirements in the Tender Process
In the tender documents IFBU points out the major environmental challenges and how these are to be met by the contracting party (consultant/contractor). IFBU also ask for a presentation of the consultants/contractors' environmental skills and how the job will be carried out with regard to the environmental challenges. This presentation will be taken into account during the assessment of the offers.

Environmentally responsible person
The contracting party (consultant/contractor) have to appoint one person in their project team to conduct the environmental aspect of the work. A CV of this person's skills must be presented as part of the tender documents, and will be evaluated as part of the assessment process.

Template for Environmental Plans
Within 4 weeks after entering into a contract the contracting party should have delivered an environmental plan in accordance with IFBU's template.

IFBU has developed a template for environmental plans to be used by consultants/contractors. By using this the contracting party is to explain how environmental aspects are considered in its own business and how it is considered in the work to be done for IFBU.

The template also ensures that an explanation will be given as for how the contracting party will implement the GEP, including the main environmental objetives and IFBU's environmental requirements. The party must also set it's own environmental objectives based on those in the GEP.

A scheme is to be attached to the environmental plan, showing the connection between the general environmental objectives set in the GEP, the objectives and requirements set by the land owners and developers, and the efforts put into effect by consultants and contractors.

As the project finishes the complete scheme will show what has been done in practice to implement the general objectives in the General Environmental Program.

To mention an example: One general objective in the GEP is to organise a flexible and energy-effective energy supply system in order to minimise the use of electricity. In order to fulfil this IFBU has set as an objective - and consequently as a recommendation to its contracting parties - always to assess energy-effective alternatives, and, if budgetary possible, always to choose these alternatives as long as less running expenses can make up for the higher investment costs within the first five years.

This makes an incentive for planners and projectors to demand for more energy-effective solutions even if they might seem more costly in the first lace.

GEP Objectives	**Objectives and preconditions set by IFBU**	**Objectives and efforts set by planners and projectors**	**Objectives and efforts set by contractors**
Organise flexible and energy-effective energy supply systems.	Always assessing energy-effective alternatives, and, if budgetary possible, always choosing these alternatives as long as less running expenses can make up for the higher investment costs within the first five years.	*To be completed by the planners and projectors*	*To be completed by the contractors*

Guidelines for how to prepare the Environmental Plans
Since few consultants/contractors have developed their own Environmental Plans IFBU offers coaching in how to prepare such plans. The contracting party (consultant/contractor) is followed up during the planning and construction to ensure that the GEP is implemented.

Courses
The contracting party is also obliged with all their project staff to attend IFBU's separate three hours' environmental course. The course focuses on the main environmental objectives in the GEP and how these are to be followed up during the actual project/work. It also points out the main challenges, the vulnerability of the area and tries to make people understand the importance of being environmentally conscious.

Monthly reporting
The contractors have to report an environmental account every month based on indicator's chosen by IFBU. These indicators are as follows:

Environmental indicators for contract: Contractor:

Period:				Date:	
Environmental indicators	***Unit***	***Total amount***	***Amount month no 1***	***Amount month no 2***	***Comments, references etc.***
Loss/waste on site of construction	Ton	0,00			
Waste, sorted	Ton	0,00			
Total amount of waste, included sorted waste	Ton	0,00			
Sorted waste as share of the total amount of waste	%				
The use of recycled materials	Ton	0,00			
The use of re-used materials	Ton	0,00			
Total use of materials	To	0,00			
Recycled and re-used materials as share of total amount of materials	%				
Materials/products subject to environmental assessment	-	0,00			
Totalt amount of materials/products used	-	0,00			
Materials/products subject to environmental assessment as a share of the total amount of materials/products.	%				
Energy use by vehicles and engines	Litres of diesel	0,00			
	Litres of oil	0,00			
	Litres of gasoline	0,00			
	kWh (el.)	0,00			
	Other energy sources	0,00			
Total number of transports to Fornebu	-	0,00			
The number of transports with empty load one way.	-	0,00			
Transports with empty load one way as a share of the total number of transports.	%				
Environmental accidents	-	0,00			

Further development
As IFBU will continue to develop the area for almost ten years from now the method will be evaluated and improved at a regular basis.

Architectural Evaluation & Operational Model as a Sustained Response on Technological Impact in an Industrial Environment

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INTRODUCTION

The American Institute of Architecture (AIA) and the Union International of Architecture (UIA) consider the sustain development to be the integration that combines the energy source and its effective use, healthy materials and buildings , pro-ecological and social sensitive land use and esthetical sensitiveness that inspire, support and ennoble.[i] The last phrase distinguishes sustain development from the commonplace argument that limits the discussed problem only to energy sources and their using. It suggests that development has the task of maintaining life together with its human aspects, as well as aesthetic, physiological , psychological and spiritual human needs. The aesthetic, beauty, health, comfort and quality of life are as important to sustain development as waste reduction, energy consumption. It could be observed the quality sense defines development in connection to architecture structure , such as buildings in a town (office buildings) and in an open landscape (industrial buildings). This kind of consciously accepted ideas concern the humanisation of the environment, ecological awarness, social sensitivity, rationality of energy consumption. Technologies must be stopped to be unconditionally glorified. The review of the chosen environmental strategies has been lately presented at the International Conference in Holland – Sustainable Building 2000 in EU Research Programs – Agenda 21, where our Laboratory of Ecological Industrial Architecture Design has presented the paper and the poster published in the Conference Materials..[ii]

SYSTEM MODEL OF THE INDUSTRIAL ENVIRONMENT

Figure 1 presents the system model of the Industrial Environment. Figure 2 shows the Input & Output of the Exploitation system as the closest environment of a factory ecological system.

Output to the Eco Factory system (Figure 2)

During the exploitation process the following relations are investigated: The relations *technology –user*. It is direct contact with a machine (technology), the relation *created environment –user* must be explained respecting the influence of the physical environment on the user which contains air, light, acoustic, kinaesthetic and space environment, the next relations are: *technology - created environment - user, technology - natural environment (geographical),* and *created environment - natural (geographical) environment.* Some explanation must be done concerning space environment – which could be appreciated according to the dimensions and shape of the object skin, the vertical & horizontal form of the space, as well as architectural values as e.g. the space of the function and perception. In the evaluation of the space environment close to the measurable criterions some psychological criterions could appear as semantic characteristics of the space that contains the visual expression of an architectural function, production, building material, semiology of light and colour, hearing perception and movement perception. Moreover the proxemic characteristic could be considered as the concept of distance or remoteness. The kinaesthetic environment in the definite space could be appreciate according to psychological criterions connected with

the decision making process of the user, sensory information, memory information and statistical information.

Geographical environment (Figure 2)
The geographic environment surrounds the built space structure (buildings, transport & production objects etc.). It is evaluated by such criterions as: air temperature, heat radiation, rainfall and cloudiness, humidity, air movement and contamination. Monument & archaeological objects, and layout, ecological & geological values are also considered.

THE ELEMENTS OF THE ECO FACTORY SYSTEMFigure 3 represents the elements of the Eco factory system. The state industry renewing & modernisation must to be agreed as the objectives of social and economic development. First of all, there are competitiveness, effectiveness, sustainability, ecological responsibility, etc. Architecture plays one of the major roles in the creation of a human friendly industrial environment, (the subsystem of human ecology).
The subsystem of factory ecology could be considered according to some chosen negative & positive reactions to the industrial plant system surrounding.

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THE MAIN ENVIRONMENTAL PROBLEMS AS ELEMENTS OF THE INDUSTRIAL ENVIRONMENT SYSTEM
Some chosen problems concerned the elements of the system are presented in Figure 4. and are numbered as follows: (1) The ecological knowledge potential of the information base. (2) The capability of the design process participants. (3). The Architectural & Eco value context of the design. (4). The problems of energy, materials, devastation of land, burdensome to inhabitants, architecture values etc. (5). The influence upon Eco & Architectural characteristics of the environment, architectural function, utilisation, urban planning, technology, ecosystems, archaeology, geography, aesthetics etc. (6) The danger of contamination, accidents, burdensome to inhabitants, the danger to Eco-systems etc. (7). The same as in point.6 (8). The same as in point.6. (9). Problem of individual & social health, economy, etc.

TECHNOLOGICAL IMPACT ON THE INDUSTRIAL ENVIRONMENT
Figure 5 presents six different actions (A,B,C,D,E,F) stimulated by their environmental input representing the technological impact on the Industrial Environment System. The schemes represent the reaction structure. There are positive reactions causing the desired states of the Eco Factory System or negative reactions which need counteractions. There are also complex reactions that could be partly negative from the view point of the industrial environment system., but they are positive economically, socially etc.

A. The geographical environment reaction
Some characteristics : Too intensive building-up that has influence upon temperature and dryness, difficulties of the wind direction control of the territory, excessive solar radiation, the temperature in the shade, general temperature & humidity, air quality, the role of greenery and water surfaces.

B. The exploitation process reaction
Some chosen characteristic: The danger of accidents, heavy physical work, troublesome precision work, transport & control, work affecting the nervous system, human reactions on the introduced work organisations.

C. The physical environment reaction
Some chosen characteristic: work organisation problems, insufficient back-up technology, etc. The physical environment reactions problems: e.g. the interior traffic, air contamination, insufficient lighting, extensive noise, e.g. intensificated danger caused by mutuall reactions.

D. The exploitation process & the physical environment complex reaction
This scheme indicates mutually connected reactions both from the physical environment and natural (geographical) environment. The exploitation dangers are reinforced by the dangers caused by the physical environment. (i.e. the heavy physical works performed in the noise & humidity environment).

E. The feed back complex reaction to the exploitation process.
The *feed-back* phenomena causing the aggravation of the exploitation conditions.

F. The complex reaction caused by the wear and tear of the Eco-Factory System elements
It changes the values of the system, its input elements, and their reactions.

SUSTAIN RESPONSE IN AN INDUSTRIAL ENVIRONMENT SYSTEM
Four types of the optimisation model are presented on graphic schemes G, H, I, J (Figure 6).
G.-Full elimination of the technological impact from the exploitation process and the physical environment. For instance, full automation, new methods of work etc.
H.- The elimination countermeasure due to the blockade of the information channels of the system. e.g.. the elimination or factory risk objects isolation etc.
I.- The partiall limitation a state of emergency from the side of the exploitation process and from the side of the physical environment
J – The last scheme from the optimization hierarchy. It is the most popular on the industrial environment system. when it is difficult or even impossible to eliminate main factory dangers. In such a case, it leaves only substitution. It means give users different values that can compense for the wrong working conditions.

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Discussion of the Development and Assessment of the contemporary Ecological Residential Districts in China

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1. BACKGROUND

In the recent 2-3 years, while exploring the ways of construction for a more sustainable environment, Ecological Residential District (ERD) is put forward as a new concept and attracting increasing attention in the Chinese residential real estate market. When more developers tend to use "ecological" as their sale-points, the requirements for the scientific assessment and official identification of ERD becomes stronger than ever. As a response, from late 2000 to mid 2001, several ERD assessment systems were proposed and initiated by different regional research groups.

This paper firstly introduces one ERD project in Beijing, and analyzes the problems of the development and requirements concerning the assessment of current ERD project in China. Then, three systems under developing are introduced, in which one of them is identified as more holistic and properly focused approach. Finally, further researches for regionally proper ERD assessment system are recommended.

2. ERD PROJECT IN BEIJING

Beiluchun Residential District was designed and realized as a leading example of ERD project in China. It is valuable in demonstrating the ability and emphasis of the regional ERD practices and providing possibility of benchmark selection and system validation for the ERD assessment in the region. Its main ecological features include:

2.1 Energy Efficiency

The thermal performance of the residential buildings are enhanced by using the composite

multi-layer construction technology; the outdoors and windows are double glazed; ventilation layer are added to roof of the top level to reduce heat gain in summer time. All the effort had been made possible for cutting energy consumption by half compared to the “normal” design.

2.2 Water Efficiency

A gray water treatment system with the capacity of recycling all the 640 tons of gray water produced from daily life for the use of planting, automobile washing and fire protection is introduced into the district. The redundant part or the gray water is imported to an artificial lake, which is constructed mainly aims at storm water collection, and has a funnel form basement that can penetrate the collected water back to the land, helping maintain the underground water level on the site.

2.3 Land Conservation

The site is a billabong which is 2 meters lower than its surrounding area. Filling the site to ground level would damage large amont of soil material. To save land, an aerial platform system was designed to provide connection methods, parking space (underneath) and leisure space for the residents in the district. The land saving is also achieved by abolishing the use of soil brick for building construction material.

2.4 Pollution Prevention

An advanced ’garbage burning stove’ for environmental protection was imported in the site to burn the daliy solid wastes in the district(Jintian Architecture Design Company, 2001)

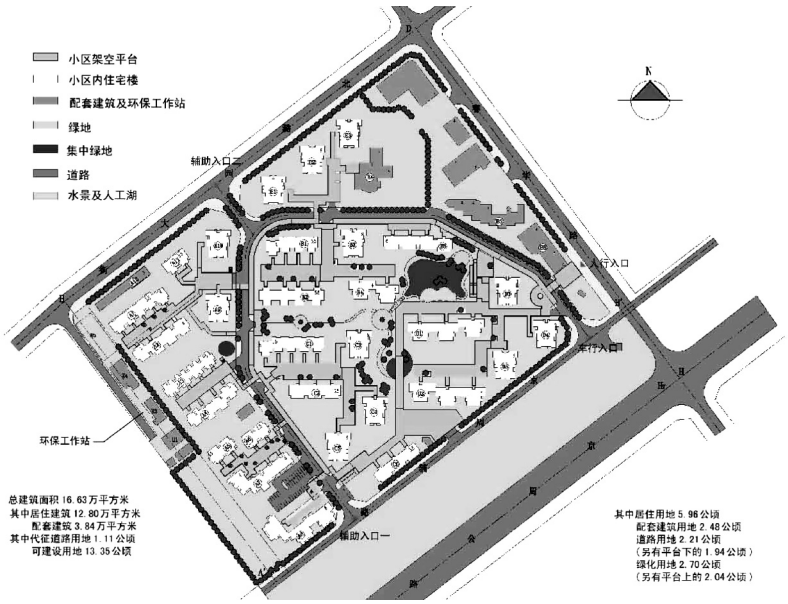

Figure 1 Master plan of the Beiluchun Residential District, Beijing, China (original provided by HUANG, Hui, chief architect of the Jintian Architecture Design Company)

3. PROBLEMS AND REQUIREMENTS

While the above case represents the efforts of regional best practice, the general conditions concerning the ERD development in China is still complex. Following are the problems

revealed from our recent field investigation in Beijing and Xi'an, and analysis of the relevant requirements for the ERD assessment

Firstly, there is a visible trend of using 'ecological' or 'green' as sale points in the residential real estate markets. However, few of the projects can be identified as ERD from a holistic ecological point of view. This happens either due to lack of understanding or misemployment of the concept. To properly regularize and direct the ERD development, clear definition and scientific assessment of ERD is necessary and important.

Secondly, the ERD development in China is still in its preliminary stage. So, new eco-technologies and materials are less than sufficient in the market, and ecological building experts and experiences still lack in the design companies. It is important that the assessment should consider the regional ecological building possibilities, at the same time encourage every positive effort towards ERD development. It is also necessary that the system be opened and dynamic in the way that it could be complemented along with the future ERD development.

Thirdly, there are many variations of regional conditions in China, which present climate, culture, economic, technology, even the ambitions of the developers, etc. So, a flexible mechanism to suit the varieties is essential.

To summarize, we realize that the strategic functions of the current ERD assessment in China are required to be *encouragement*, *regularization* and d*irection*, and characters of the assessment system are necessary to be *flexible* and *dynamic*.

4. ERD ASSESSMENTS IN CHINA

From late 2000, several regional research groups have been working on different ERD assessment systems in China. We analyze the following three of them (Table 1 shows their main indicator structures) in this paper:

1) The Main Construction Points and Technology Guidelines for ERD in China (GERD)(Wang. Y.H., 2001);
2) The Construction Outline for Healthy Residential Buildings (COHRB)(Kai, Y, 2001);
3) China Eco-Housing Technology Assessment Handbook (CEHTAH) (Nie M.S., Qin. Y.G., Jiang, Y.,Song, T.X., 2001).

4.1 GERD

As the first proposed ERD assessment system in China, it is meaningful in demonstrating the comprehensive concept of ERD and marking the startup of an important ecological environmental concerned approach of building assessment in the country. Insufficient consideration of the complexity and applicability regarding the regional condition of practices is argued as the main weakness of it, since all its ten assessment categories are set equally, and many of the criteria are set strictly, which means it is possibly difficult to be achieved in the current regional practices.

4.2 COHRB

This is a human oriented and health focused assessment system, in which the ERD projects are assessed according to their physical and psychological affections of human being. It is special in providing more criteria and benchmark details in the *living environmental quality*, *management* and *service*. However from a sustainable point of view, lack of consideration about the "resource consumption" and "environmental loading" indicates its major limitation.

Table 1 Indicator Structures of GERD, COHRB and CEHTAH

GERD	COHRB	CEHTAH
1. General Principle 2. Energy 3. Water 4. Air 5. Sound 6. Light 7. Thermal 8. Afforest 9. Waster disposal and management 10. Green construction material	1. General Principle 2. Human Environmental Healthy - Outdoor environment - Quality of occupancy space - Air Quality - Heat Environment - Sound Environment - Light Environment - Water Environment 3. Natural Environmental Affinity - Nature Environment - Green System - Rainwater Utilization - Landscape Water 4. Residential Environmental Protection - Vision Environment - Drainage System - Grey-water System - Waste - Environmental Sanitation **5. Healthy Environmental Guarantee** - Environmental Guarantee - Recreation Facility - Medical Treatment Facility - Aged Person Service - Healthy Activity	1. General principles 2. Environmental plan and design - Site selection - **Transport** - **Convenience for construction** - Greenization - Air quality in the district - Sound pollution - Sunlight and illumination - **Microenvironment** 3. Energy and environment 4. Indoor environmental quality 5. Water environment in the district 6. Material and resources

4.3 CEHTAH

Inspired by LEED and learned from the GERD**,** CEHTAH presents a relatively more holistic and properly focused approach for the ERD assessment. Firstly, the content and organization of its six indicator categories demonstrate a balanced consideration of human being and the environment; Secondly, more indicators, like *transport*, *convenience for construction* and *microenvironment*, are included under its special design and plan category; Thirdly the focus of the system, like *energy*, *water*, *material &resources* and *indoor environmental quality*, properly reflect the ability and emphasis of current regional ERD practices (see the main ecological features of Beiluchun Residential District in part 2 of this paper).

When evaluating the above three systems according to the specific requirements for the regional assessment (see "3. Problems and Requirements" in this paper), we consider that, by providing the indicator structures, they basically demonstrate the *regularization* and *direction* functions. The remained questions are: 1) How to realize the encouragement strategy? 2) In what way can a flexible and dynamic assessment be properly achieved?

5. FURTHER RESEARCHES

ERD projects are generally very complex, which implies that simple indicator frameworks are unlikely to satisfy the requirements for the holistic assessment of them. However, the complexity of the assessment structure should be dynamically compatible with the stages (levels) of the regional ERD development (see Chat 1), so that the required data can be collected and most of the positive effort in regional practices, especially those in the early stages, can be properly identified and *encouraged*.

So our exploration of a regionally specific ERD assessment system in China will start from a simply style with a concise structure to suit the generally preliminary stage and a clear focus to reflect the efforts of regional practices. More comprehensive structures will become necessary when the regional ERD development achieve higher levels (like in Beijing, Guangzhou and Shanghai, etc).

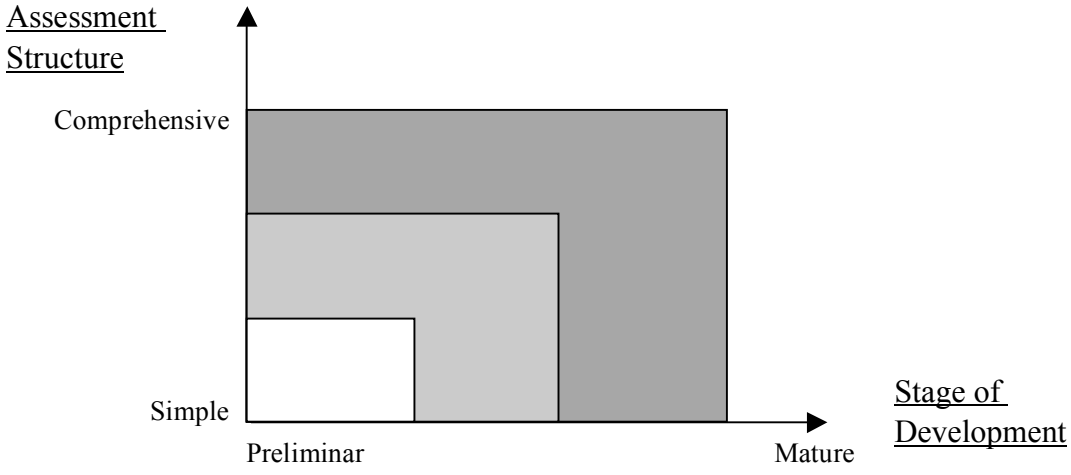

Chart 1 Complement the assessment structure from simple to comprehensive styles that are compatible with the stages of ERD development.

Finally, a set of assessment systems with different levels of complexity is supposed to be established to suit the variety of regional conditions and requirements. At next stage, a pilot study will be conducted to explore the proper system for ERD assessment in Beijing, in which the Beiluchun Residential District will be assessed in detail. The proposed system may form a basis for assessing Olympic Housing Performance as part of its green agenda. More results will be presented in our future papers.

6. CONCLUSION

This paper discusses the contemporary ERD development and assessment in China. One of the best practices is presented, the general problems in ERD development and requirement for the ERD assessment are analyzed, existing assessment systems are reviewed, and their problems and limitations are identified. Further resarch is aimed at establishing a set of assessment systems with different levels of complexity to suit the variety of regional conditions and requirements.

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Future C&D waste recycling in Norway – Learning from Danish experience?

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1. INTRODUCTION

The overall target for construction and demolition waste recycling in Norway is set to 70% by 2005. Today only 10% of our building waste is recovered at the national scale (25-50% in the Oslo region). In contrast Copenhagen in DK, have reached 98% recycling of construction waste. This article uses system perspective within an Industrial Ecology (IE) framework as a tool to develop a qualitative model to describe the technical environment and social evolution of the recycling system for construction waste as implemented in Copenhagen. With this approach we have identified the most important conditions behind the overall success, in terms of technical, environmental and economic parameters of the Copenhagen model. We have compared these findings with status quo in Oslo and the rest of Norway.

There are important differences in building traditions, demography and geography between Denmark and Norway. The most important differences however are founded in attitude, organizational framework and the will to use the potential in the positions of municipal and national authorities.

2. METHODS

In our study of the evolution within the recycling system in Copenhagen, focusing on the systems environmental performance, we have used standard systems engineering (SE) methodology (Olivier *et al*. 1999) to establish and verify an organizational and a qualitative model of the system.

2.1 Assessment of information

We have assessed information by studying waste statistics, standards, official studies and by interviewing representatives for all stakeholders in the system. The results were then compared with the proposed future change and plan for C&D waste in Norway for 2005.

2.2 Measure of effectiveness

In order to determine system performance, one needs to define a measure of effectiveness. Sproles (2000) defines measures of effectiveness (MoE) as: *"standards against which the capacity of a solution to meet the needs of a problem may be judged. The standards are specific properties which any potential solution must exhibit to some extent. MoEs are independent of any solution and specify neither performance nor criteria"*. In the recycling industry, % weight is commonly used. All waste statistics in Denmark are based on a system using weight called ISAG (E.K. Lauritzen 1996). However, this indicator is not a MoE, rather a measure of performance (MoP), which also is not capturing environmental performance.

Thus the Danish system does measure MoP, and must therefore develop indicators in order to give estimates on environmental performance or MoE.

This is of crucial importance. Eik et al. shows that % recycling has low value in terms of environmental performance. They argue that in order to evaluate any recycling systems, one needs to develop generally applicable and system specific indicators (Eik et al. 2002). We think that eco-efficiency would be a better MoE. There are several definitions of Eco-efficiency (WBCSD 2000, NFR 2000, OECD 1998), and in our context we propose to use the WBCSD definition:

$$\text{Eco} - \text{efficiency} = \frac{\text{Value added}}{\text{Environmental influence}}$$

In order to develop eco-efficiency data on the system, one needs to determine which indicators to use and quantify these. We suggest the following indicators for our system:

- Costs (negative value)
- % recycling
- CO_2-emissions
- Energy consumption
- HTP (Human Toxicity Potential)

2.3 Information models

By using a system perspective within an Industrial Ecology (IE) framework, and thus follow the activities connected to the mass flow of the system, we have been able to identify the most important conditions behind the overall success, in terms of technical, environmental and economic parameters.

3. RESULTS

The C&D waste recycling system in Denmark, and Copenhagen in particular, is well documented (E.K. Lauritzen 1996, Nejrup 1999). Although there is historic documentation of recycling at earlier stages, the recent system is a result of the EU and the following Danish environmental protection act from 1986 (E.K. Lauritzen 1996). The Danish environmental protection act of 1986 distributes power to local authorities and municipalities, and the present system of Copenhagen is the results from years of iteration between municipalities and stakeholders. It is, however, necessary to remember that the local power is restricted to how to organize waste handling and on giving necessary permits to actors. The law clearly forbids any deposition of waste in general, and the government decides on the level of taxation. The findings suggest that the most important policy instruments are:

- Waste tax (national), which allows authorities to use tax laws to prosecute those who break the law.
- A civil law contract between municipalities and certified actors (Copenhagen).
- Compulsory notification of waste and a waste management plan prior to demolition, necessary in order to obtain a demolition permit. (Copenhagen).
- Standardization of selective demolition practice, NMK standard (national).
- Implementation of the polluter pays principle; house owner is responsible for the waste, even though he may hire somebody else to do the work..
- Compulsory separation of waste fractions for all who produce more than 1000 kg of waste (Copenhagen).
- Mixed fractions in waste transport are prohibited (Copenhagen).
- Quality control system, by using the receipts from waste delivery.

Of the above mentioned policy instruments, the most important one is the waste tax. It is documented that the degree of recycling and energy recovery follows the level of taxation (Figure 1).

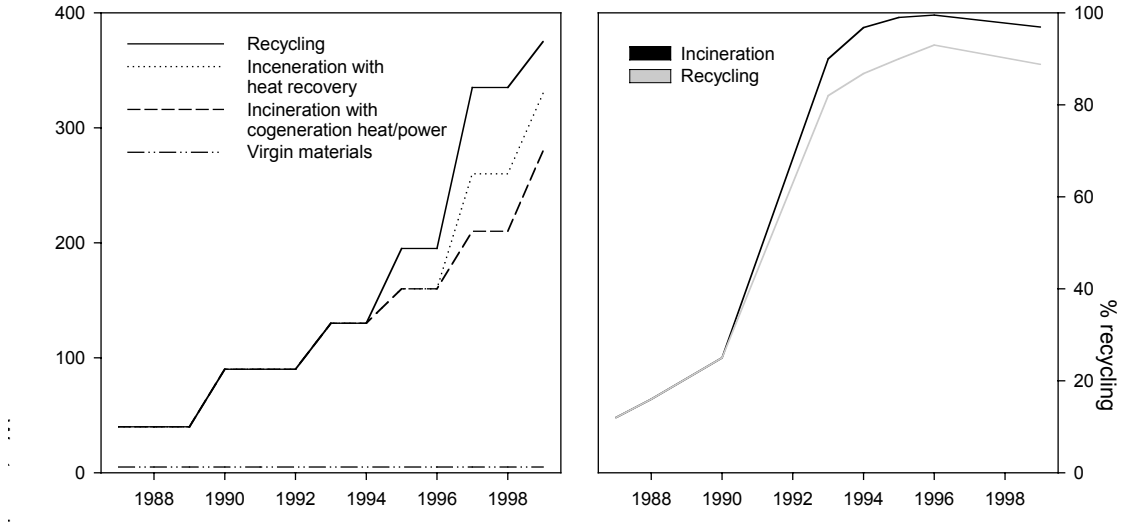

Figure 1. The historic relationship between waste taxes and recycling or energy recovery in Copenhagen, DK.

It must be mentioned here, that the tax is only a part of the cost of the waste handling, but the cost of handling is exposed to competition among private actors in the system and thereby not fixed. Our findings suggest that profit is associated with sorting and processing activities, not transportation. Large companies dump prices on transportation, receive mixed fractions of waste, and demand waste tax from the waste producer, and finally separate waste into pure fractions to be delivered for (tax free) recycling. The dividends will then make the profit. Interestingly, if we break down the waste stream into the different fractions, and compare this with the separation of taxes for the corresponding fractions, one can see that tax levels are effective policy instruments for the management of the waste system.

A weakness with the Danish (and most other recycling systems) is that they lack information on environmental performance in a system-wide context. Although some of these data exist, they are collected nonsystematically and are not used for analytic purposes. We recommend that both Danish and Norwegian authorities start measuring and using eco-efficiency indicators in order to evaluate their respective recycling systems. Such values could then be used in a simplified quantitative model, i.e. such as following the change in aggregated CO_2 emissions, in order to increase environmental performance. (Figure 2):

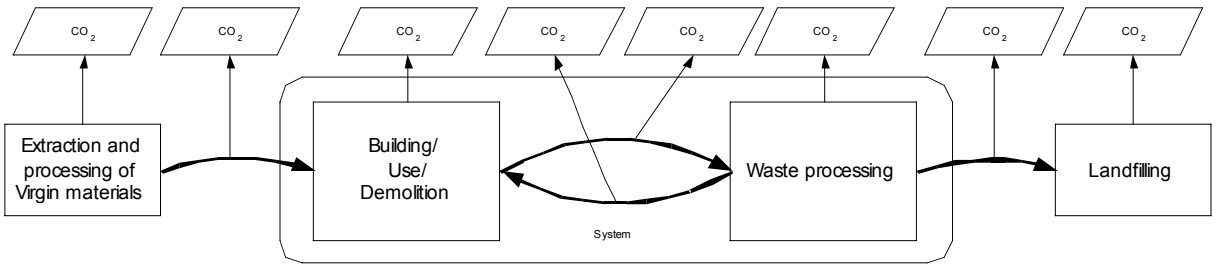

Figure 2. A simplified model for evaluating environmental performance (CO_2-emissions) in a C&D waste recycling system.

It is easier to identify where changes in CO_2 emissions have occurred, and where new improvements can be made, through the simplified model in Figure 2. Most of the recycling, > 90 %, is actually "downcycling" of brick and concrete by crushing. CO_2-emissions from this process equals the emissions from extraction and processing of virgin materials. Since the materials are downcycled, there is no "change" in CO_2-emissions from the Building/Use/Demolition phase. Hence this leaves two actions where emissions are reduced, namely transportation and landfilling. Numbers show that both lorry transport and CO_2-emissions from landfills have been reduced with 80% (Nejrup 1999). The challenge is now to improve the system by focusing recycling instead of "downcycling", and thereby reducing emissions from both extraction and the Building/Use/Demolition phase of the material cycle.

By following the materials through the system we have also outlined a qualitative model of the recycling system, which more directly emphasizes flow of information among actors and activities, see Figure 3. Through literature studies (E.K Lauritzen 1996, Nejrup 1999) and interviews we have been able to trance communication pathways, quality control systems and laws and standards that affect the different stakeholders. These are built into the Figure.

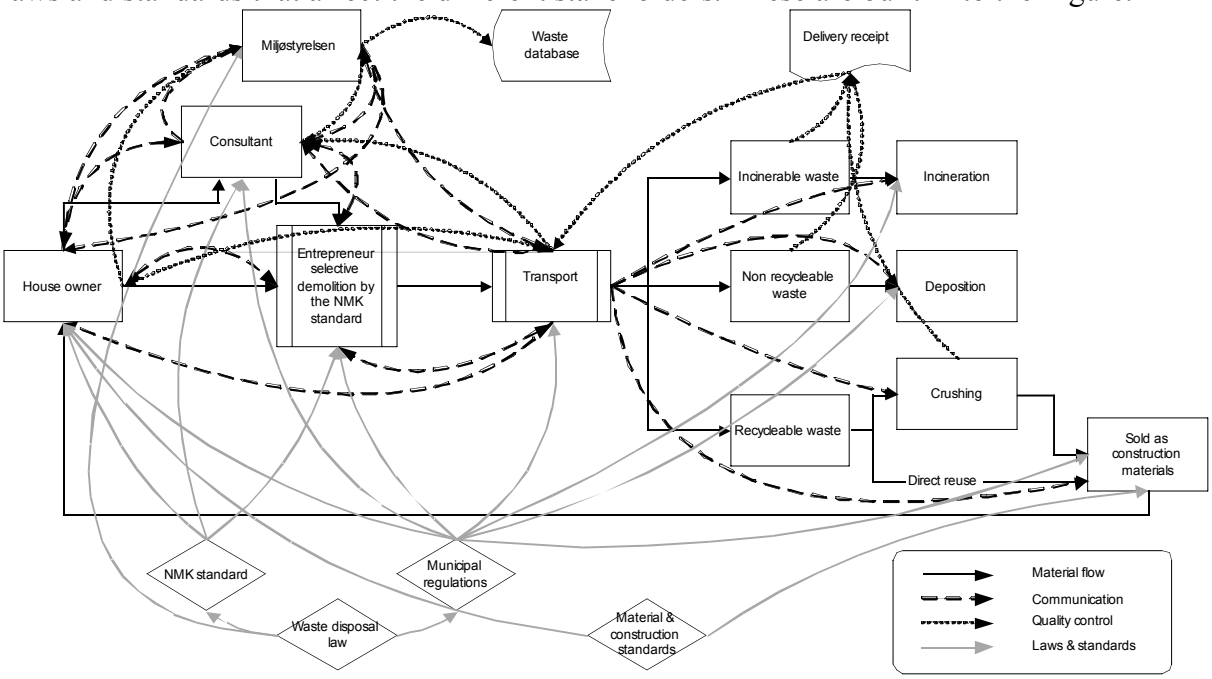

Figure 3. Information flow for the C&D waste recycling system in Copenhagen.

As can be seen from above, transporters have a key position in the environmental performance of the recycling system of Copenhagen. Hence, from a systems engineering point of view it is desirable to focus on the transporters' situation in order to enhance the overall system performance. The interview identifies the many different municipal regulations as the first area of focus. If the certification would be at the national instead of on the local level, so that the municipal authorities was left with what to do, not how to do it, further environmental and economic improvements could be made.

4. DISCUSSION

At first glance it may seem that the system for C&D waste recycling in Copenhagen is functioning quite well, and with regards to % waste recycled it does (MoP). Yet detailed literature studies and interviews of stakeholders suggest that the result of the strong policy actions from the municipalities in Copenhagen and elsewhere in Denmark lead the system

into several “lock ins” and a following sub-optimization of the overall environmental performance (MoE) of the waste recovery system.

Worth mentioning here are two “lock ins” that effect the system in different ways. The first lock in is the local practice of using civil law contracts between (cant get certificate without) municipalities and certified actors, in this case the transporters, and the strict practice of which material companies which is certified to receive the C&D waste. This leads to suboptimal use of transport, and thus higher CO_2-emissions than necessary. Since each municipality in Denmark has their own rules and regulations, some transport companies have to be up to date on as much as 40 different rules and regulations on waste transportation alone.

The second lock in, is the satisfaction of a well working system. There are little or no existing incitements to improve the system. Since the only MoP used is % waste recycled, one fails to ask whether the system is performing good or not according to MoE. The system and its stakeholders then goes from a learning II type of organization (where one tries to improve performance) back to a learning I type of organization (where focus is on maintaining positions) (Senge 1990, Argyris & Schön 1985).

In comparison, even though the technical recycling potential in Norway is 95 % (Grip/Økobygg 2000), the proposed action plan for the minimization of C&D waste in Norway suggests that one should concentrate on the main cities (Grip/Økobygg 2001), since it would neither be environmental nor socio-economical reasonable to implement a such high recycling rate on average due to large transport distances. It is possible to reach a recycling rate in Oslo, where half of the C&D waste in Norway is generated, as well as some other cities, of 80-90% in three years, which would give an average C&D waste recycling in Norway of 70% within 2005 (Grip/Økobygg 2000). Table 1 shows the different policy measures planned an implemented in Oslo versus Copenhagen.

Table 1. Policy measures planned an implemented in Oslo versus Copenhagen.

	Oslo		**Copenhagen**	
	Policy instrument	Status	Policy instrument	Status
Local level	Compulsory notification of waste and waste management plan prior to demolition	Impl.	Compulsory notification of waste and waste management plan prior to demolition	Impl.
	Quality control system	Impl.	Quality control system	Impl.
	Denial of certificate of practical completion until waste disposal is documented	Impl.	Denial of certificate of practical completion until waste disposal is documented	
			Certification of actors	Impl.
			A civil law contract between municipalities and certified actors	Impl.
			Illegal to transport mixed fractions	Impl.
National Level	Waste tax	Impl.	Waste tax	Impl.
	Implementation of the polluter pays principle	Impl.	Implementation of the polluter pays principle	Impl.
			Standardisation of selective demolition practice	Impl.
			Illegal to deposit waste in landfills	Impl.

5. CONCLUSION

The success of the C&D waste recycling system in Copenhagen is mainly due to use of waste taxes, standardization on selective demolition and a general ban on deposition in landfills. At the local level the strict regulations and certification of transporters has contributed significant. But the lack of documentation on indicators of environmental performance other than % waste recycled, has led the system into a side track where no further developments takes place. The delegation of regulating power to the municipalities has, however, also led to a sub-optimization of the system, due to unnecessary many different regulation schemes. We therefore suggest that the upcoming Norwegian system for C&D waste recycling should follow the Danish example, with two important exceptions:

- To avoid sub-optimizing and "lock ins", one should delegate the power to certify actors to a national body. Local authorities should still regulate what to do, but not how and where.
- To analyze system performance one should collect data on indicators from the start.

6. AKNOWLEGDEMENTS

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A Critical View to the Concept of Sustainable Architecture in Turkey

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1. INTRODUCTION

Turkey has very limited number of examples, which are characterized as sustainable building. In spite of the fact that is hard to develop a critical approach within this limited scope, the current examples have potentials enabling to observe the panorama of sustainability and sustainable architecture in Turkey. Initially, they indicate unique architectural solutions belonging exclusively to the country towards the primary strategy on reaching a sustainable built environment; that is "think global, act local".

Sustainable Building efforts can be evaluated within the context of sustainable development process of the world. The concept of sustainable development was first related with economically based approaches proposing the revision and regulation of current development process of nations without stemming the growth. Dealing with its conceptual change after the declaration of Brundtland Report in 1988, the scope of sustainability was enlarged as not only being related with 'economical prosperity' but also the 'social development'. Therefore, the guideline of sustainability deals with systems and problems intensified by the situation from societies living beyond its means.

Sustainable principles propose to re-regulate the high standard of living in many developed countries whose societies have unsustainable way of life. At the same time, they empower the life of developing countries to attain better living conditions without damaging the environment. The guideline is formulated on the basic trio of economical, ecological and social development in terms of sustainability for all developing and developed countries.

Within the scope on criticism of sustainable architecture in Turkey, the fundamental approach should be to consider the economical, social and ecological peculiarities contemplating the fact that Turkey is a developing country. The continuing ruralization and urbanization policies, priorities given to economical development efforts and westernization of social life directs the comprehension of sustainability and its architectural practices of Turkey.

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2. THE CONCEPT OF SUSTAINABILITY IN TURKEY: THE SHORT PANORAMA

The United Nations Conference on Environment and Development, held in Rio de Janerio of 1992, was the first conference which governmental boards of Turkey agreed with and promised officially to realize the sustainable development goals in its development process. The formal body of this conference promoted to form the local working groups towards sustainability. The local agenda 21 studies in Turkey, therefore, were the preliminary attempts to implement the sustainable principles in terms of economical, social and ecological aspects. They raise the acceleration of local studies and thus, enable to form action plans of cities for the next century.

The Second United Nations Human Settlements Conference (Habitat II), held in İstanbul of 1996, allowed giving extra attention to the concept of sustainability in Turkey. Both the earlier preparation phases and the discussions through conference enabled to understand the importance of sustainability and introduced the concepts of sustainable settlement and building. The discourse of conference was dominated by habitat and human settlements. Thus, it focused largely on the concepts of global village, mega city and human settlements aiming to nurture a healthy and sustainable habitat and human settlements. As a result, most of cities in Turkey had their own local agenda 21 groups encouraged by local governmental organizations. The conference also caused to increase in the number of non-governmental organizations studying on sustainability and researches in universities (Atauz, 2000: 194).

3. SUSTAINABLE ARCHITECTURE IN TURKEY

Even if the term "sustainability" has become a global concept for 10 years, it has still been a new subject for Turkey. Its scope is not appropriated adequately by both the governmental and non-governmental organizations in Turkey; at least as expected as after the last Habitat II Conference. Thus, the acceptance of concept towards the sustainability of life has needed an adaptation period, yet.

The one of most important reasons is that there is no active governmental involvement for establishing a sustainable built environment in Turkey. Political efforts towards the sustainable way of life are inadequate. Moreover, there is no valid architectural or planning policy promoting the sustainable architectural production. The examples of sustainable architecture in Turkey, therefore, are very limited in comparison with the existent building stock.

Within this scope, the sustainable buildings of Turkey indicate the importance of individual efforts, rather than governmental efforts, without representing any policy of Turkish Government on sustainable architecture. Most of them are built by non-governmental formations. The efforts in relation with the sustainable examples in Turkey are classified as follows:

- Individual efforts: Personal or communal efforts, i.e. NGOs, special formations,
- Governmental efforts: Local or central governmental organizations, i.e. researches by governmental universities.

Sustainable building examples in Turkey are generally the projects in building scale, mostly located on rural regions. There are limited numbers of operations for urban regions in both urban design and city planning scales. The building codes have also not been re-organized yet according to sustainable principles. The only regulation for "Heat Insulation" is not applied in buildings properly because of the incapability of supervision by local governmental boards.

At last, sustainable architecture in Turkey reflects varied regional conditions and priorities, and different models for implementation including both imitations and authentic ones, while most of them are spontaneously developed by non-governmental efforts.

3.1. Sustainable Architecture in Turkey by Individual Efforts

Majority of buildings typified as sustainable were built by individuals and non-governmental organizations in Turkey. Especially after the United Nations Conference on Human Settlements held in İstanbul, 1996, the new local organizations and groups of people living in

big cities has started to interest in the scope of sustainability. They search for possibilities to change their living habits and built environments for more ecological way. Thus, the concept of sustainability is quickly entered into architectural practice on such buildings as private houses, small housing groups, housing and public buildings for earthquake regions, ecovillages and buildings for touristic purposes.

3.1.1. Ecovillages: One of the most important problems experienced in all developing countries is the problem of migration from rural to urban areas. The same problem has been increased in Turkey since 1950s. This uncontrollable movement to cities caused to unplanned and unhealthy growth of urban life and crisis in cities. Except for continuously migration and growth of slums, there were other problems seen in cities such as visual pollution, infrastructure problems, lack of housing, impropriety of current housing stock, high density of urbanity and unsupervised building process.

Most of the inhabitants living in big cities of Turkey experienced dissatisfaction because of the existent city life. The certain reaction to the urbanization process concludes to rise up of the individual building efforts for a sustainable way of life.

In this respect, ecovillages in Turkey are revealed because of both a necessity to live in more sustainable way and to form an alternative settlement model. They react to the reality of grimy modern cities in terms of their living conditions and social life. The village, therefore, examines to engender a small-scale settlement, not in an urban form, giving importance both to person, his /her self-improvement and communal life towards the ecological point of view.

Ecovillage movement progresses newly in Turkey. The groups behind the ecovillage movement are mostly non-governmental associations, directly related with the concept of sustainability. They prefer to create a new built environment rather than conversion of an existent one. Despite the lots of groups intend to realize an ecovillage, there are only three members registered to Global Ecovillage Network (GEN) in Turkey (http://www.gaia.org/services/Profile/Europe/Turkey/):

- Harman Balaban Ecovillage, Ankara
- Ankara Sun Village, Ankara
- Ekofoça: Foça Ecological Village, İzmir (Fig. 1)

The ecovillages of Turkey are planned as low-density settlements located in rural areas closer to big cities, which are possible to do agricultural facilities. Their economical scheme bases on to be a self-sufficient system, so the primary source of income is the ecological agriculture and different kind of educational facilities. Moreover, it is important to respect local cultures and vernacular characteristics of the region in which they locate. Most the buildings, therefore, are constructed with local and recyclable materials such as timber, stone and mud-brick.

There are several ecovillages which can step to the building and planning phases. Since the building regulations in Turkey limit alternative ownership models, the organization process of an ecovillage is slower than any kind of building process. The realization of an ecovillage can only be possible if the organization statute is cooperative. Even if there are some ownership problems of ecovillage members according to the permission of Turkish Laws, all projects have development potentials.

Hocamköy Ecovillage Project, Anatolian Ecological Communal Life Movement (http://hocamkoy.metu.edu.tr/), was the first ecovillage formation in Turkey, constituted by a group of young people from universities to create new living and production model in Hasandede town, Kırıkkale in the middle parts of Turkey. In this project, the aim was to find practical solutions to immediate ecological problems in Anatolia, solutions developed in cooperation with local peasants and farmers. One such problem is large-scale migration of villagers looking for a better life in the cities, where they settle in slums with little infrastructure. Hocamköy being a self-sustaining village tried to provide an alternative, in a form directly relevant to the villagers. As well as having a role in the human community, the project also intended to get back the destroyed parts of the barren lands of Central Turkey by ecological restoration and occupying a niche between ecosystems (Fig. 2).

The land studies of the Hocamköy Ecovillage Project concentrated more on restoration of the field, agricultural facilities and building a mud brick house. The project was continued between 1996 and 1998. Besides, there were two projects of Hocamköy Ecological Life Cooperative, funded by United Nations Development Fund (UNDP), Global Environment Facility (GEF) as follows:

- Use of Renewable and Local Energy in Rural Areas and Small Settlements in 1998 on a Community Level (http://www.undp.org/sgp/cty/EUROPE/TURKEY/pfs3714.htm)
- Training Centre for Sustainable Livelihood in Hasandede Ecovillage in Central Anatolia (http://www.undp.org/sgp/cty/EUROPE/TURKEY/pfs4233.htm)



Fig. 1. Ekofoça: Foça Ecological Village, İzmir (photograph by Zeynep Arsan)

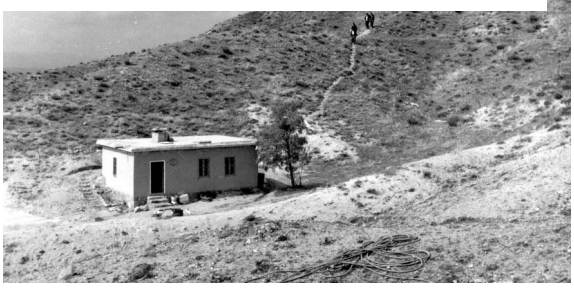

Fig. 2. The first mud brick house of Hocamköy Ecovillage Project, Kırıkkale (photograph by Zeynep Arsan)

Hocamköy Ecovillage Project was ended in 1998 and then, transformed into Harman Balaban Ecovillage Project, Ankara. The goals and the structural body of Hocamköy Ecovillage Project contributed as a model for the next ecovillages, and provide practiced knowledge for creating new ecovillages in Turkey.

3.1.2. Sustainable Buildings in Regional Context: A traditional settlement is able to present sustainable features as a source of inspiration for new buildings. Both its life cycle and built environment reflect the evolutionary characteristics that belong completely to the region. Actually, vernacular building experience is a basis for sustainable building in regional context. In this scope, the old discussion, 'new buildings in old settlements', comes out to be examined from the point of view on ecology and sustainability. The most popular approaches of 'Contextualism' and 'Regionalism' in architectural milieu of 1980s should be revised in terms of local sustainability.

There is a rising interest to sustainable architecture in regional context indicating the reacceptance of tradition paradigm by urban citizens occupied in rural areas of Turkey. Most of the sustainable examples are private houses respecting the vernacular characteristics of the region especially with building form, dimensions and building materials. Sensitive location of building mass, at the same time, points to the contextualist coherency with the settlement pattern.

Vernacular building tradition still continues in most rural parts of Turkey. In spite of the popularity for reinforced concrete construction system, the use of local materials and traditional construction techniques fortunately sustain. The old construction tradition can also be practiced in most of new sustainable examples in Turkey. There is a reference to traditional craftsmanship and construction techniques within the use of local materials such as stone, mud brick and brick. The sustainability of local construction techniques is essential in two buildings of traditional Bodrum (Muğla) houses (Fig. 3). They have a strong tectonic quality by the local stonework of local people with qualified craftsmanship and details (Ananias, 2002; 24). Moreover, Saklıköy Hotel in İstanbul has a simple but clear architectural expression of adobe bricks interpreting the old load bearing construction technique.

Sustainable architecture, moreover, should respect the local sustainability in terms of both social and ecological aspects. Sensitivity to local cultural values, preservation of natural habitat and significance given to collective memory are important issues for the continuity of a sustainable settlement. In that sense, Ahmet Kizen House in Muğla emphasizes the local characteristics of Fethiye region both with building construction technique and the way of living in (Fig. 4). It is the building of Pastoral Valley Project concerning a self-sustainable training centre about the traditional construction techniques and organic agricultural facilities for the native and foreign visitors. The project gives importance to use of local building materials and techniques learned from Fethiye Region.

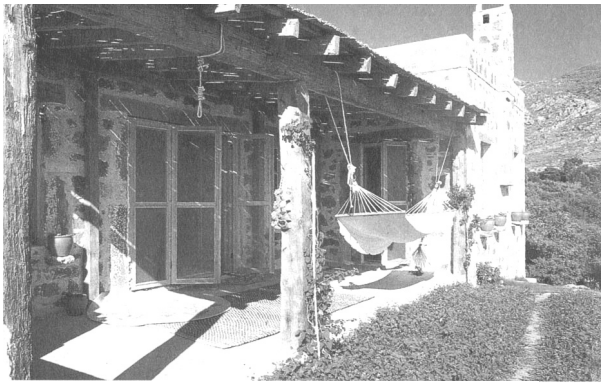

Fig. 3. House in Bodrum, Muğla (photograph by Victor Ananias)



Fig. 4. Ahmet Kizen House in Fethiye, Muğla (photograph by Zeynep Arsan)

Kırlık Village is a holiday village constituting a small Mediterranean town close to Marmaris, Muğla (Fig. 5) (http://www.kirlik.com/). It is the group of private houses constructed with stone and timber in traditional construction techniques. In spite of the respectful intention to local context, the function of houses is contrary to the concept of sustainability, since the inhabitants of the village live only in summer seasons for one to three months. The idea of secondary housing, in other words summer housing, damages the natural ecosystem in most coastal parts of Turkey. Because of insufficient planning regulations, they spread out and disturb the untouched characteristics of natural environment for a small vacation. The two storied buildings utilize architectural characteristics of Mediterranean region just as visual effect, seemingly in Post Modernist view, without serving any sustainable life expectations.

Sustainability considers the respect for local climatic factors in regional context. TÜBİTAK National Observatory Guest House is situated on completely uncultivated land far from any settlement at the top of Bakırlıtepe Mountain (2547 m.) in Saklıkent, Antalya (Fig. 6). The Observatory Complex is used both in winters and summers (Akoğlu, 1999; 52). The Guest House building notices the strong impacts of climate of this altitude, while it concerns the main function of complex. The building is constructed with local stones as a thermal storage and utilised solar energy for passive heating both in winters and nights (Şahmalı, 1998). Therefore, the building is designed in harmony with local climatic conditions using construction materials mainly available on site.



Fig. 5. Kırlık Village in Marmaris, Muğla
(from www.kirlik.com)



Fig. 6. TÜBİTAK National Observatory
Guest House in Bakırlıtepe, Antalya
(photograph by Uygar Candemir)

3.1.3. Sustainable Architecture for Earthquake Regions: Sustainability of life has become an important concept for Turkey after the Gölcük earthquake took place in Marmara region and İstanbul in August 17, 1999. Most of the reinforced buildings collapsed, thus the building practices and regulations so far had to be revised. Besides, the vital demand appeared for the accommodation of thousands of people, who lost their relatives and houses, living in the Tent Cities.

To live with earthquake is now a critical approach for designers in Turkey. The new arrangements in building sector bring forth mainly the use of new materials and construction techniques, which is resistant to impact of earthquakes. There are several efforts, experimental or practical, to concern with betterment of life expectations and maintaining life in the case of an earthquake as a natural catastrophe.

The straw-bale buildings are favoured after the disasters in Turkey because of its practical application in a short time. They are built by the cheap material, straw-bales that is easy to find and effortless to maintenance without any need for craftsmanship. The first straw-bale building built at the end of a course and workshop study on 'Straw Bale Housing for Homeless People' in the middle parts of Turkey, Hasandede, Kırıkkale (Irklı Eryıldız, 2001; 46) (Fig. 7). The one storied timber frame building is the demonstration project for the similar

housing projects in earthquake region. It is made up of straw-bale walls plastered with mud and straw, stone foundations and a timber roof on the 40 m^2 areas. The building will be occupied by the local governmental boards of Hasandede town to serve as a library or post-office of the village.

Solar House and Science Park in the United Nations Tent City, Kocaeli is the other building constructed in March 2000 by the cooperation of Clean Energy Foundation, three sponsors of private energy sector and the governmental board (university) (Fig. 7). It is financed by the project of United Nations Development Fund (UNDP), Global Environment Facility (GEF) as a permanent building at the centre of city (http://www.undp.org/sgp/cty/EUROPE/TURKEY/pfs3701.htm). The purpose of building is both the Science Park (science experiments playing area) for children living in the United Nations Tent City and to provide a lightened open area in the case of new earthquakes.

The steel building was covered with 40 units of solar collectors and photovoltaic panels of 3kW. The electricity by photovoltaic panels is operated for the illumination of building and the surroundings. The solar collectors supply the hot water of two shower cabins and washing unit closer to the building.

The open area is designed as a park for gathering place to be lightened up by the electricity produced independently in site. Since the Gölcük earthquake occurred in 03.05 at night and the electricity was cut off, it is realized that some buildings and open areas should design not to be influenced by any interruption on electricity when the unusual events have taken place. Therefore, the project was planned for the inhabitants of tent-camp to offer a safe and comfortable built environment. The inner space is functioned as a science park area including games, sets and posters about simple scientific knowledge and experiments. This function provides different social activities for people living in these tents for a while (İzmit BM Çadırkentinde Güneş Evi, 2000; 101).

Moreover, other housing projects for Gölcük region were also designed, but not constructed yet. They will be carried out by a special foundation (Yürekli, 2000; 38). The importance was given to natural lighting and passive use of solar energy for heating by trombe walls and sunspaces.



Fig. 7. The straw-bale building in Hasandede, Kırıkkale (photograph by Zeynep Arsan)



Fig. 8. Solar House and Science Park in the United Nations Tent City, İzmit (from http://www.temev.org.tr/galeri.htm)

Economical Aspects in Sustainability:

3.1.4. Ecological Tourism: Rising interest to environmentalism movement and awareness on global ecological problems orientate the tourism sector in Turkey, too. This popular concept introduced the new ideas, 'cultural and natural tourism in other words eco-tourism', for contractors in Turkey, instead of classical tourism comprehension based on packet programs with sea and luxurious hotels. According to eco-tourism principles, tourism facilities should be fulfilled first with the conservation of local characteristics of site. This tourism approach mentions the preservation of natural and built environment especially in small vernacular settlements and sustainability of ecological, social and cultural values. It aims the tourists to become conscious about the importance of local sustainability.

The buildings for ecological tourism reflect wide range of design approaches depending on the type of tourism facilities and local characteristics of the land. Some of them present local traditional construction techniques in wholly pastoral environment far from any settlement as seen in pensions group in Faralya, Muğla (Fig. 9). The other one puts emphasis to show the sustainable life of a village by living in renovated buildings at least 3 months as seen in Alternative Village Tourism and Facilities Centre, Karaburun, İzmir. Pastoral Valley in Fethiye, Muğla is also a group of pensions in which the users can work in ecological agricultural facilities and daily work. The use of old traditional timber houses to live with local people is the other approach in Karadeniz region. And last, the holiday can be carried on a beautiful natural area, but in totally artificial village atmosphere within the scope of a packet program in Naturland Eco Park & Resort Hotels in Kemer, Antalya (Fig. 10) (http://www.naturland.com.tr/indexe.htm).



Fig. 9. Pensions group in Faralya, Muğla (Photograph by Zeynep Arsan)



Fig. 10. Naturland Eco Park & Resort Hotels in Kemer, Antalya (Photograph by Zeynep Arsan)

Most of the practices built for ecological tourism facilities in Turkey consider the traditional building technologies of the region in terms of location, settlement pattern, street-building relations, building form, materials, connection details and some cultural properties. In contrast, the others present imaginary built environments, i.e. in Naturland Eco Park & Resort Hotels, Antalya, which do not belong to the context of the region. Popular tourism approaches give rise to imitations by the way of inconsideration of architectural syntax and disrespect for vernacular pattern. The eclectic design approach to traditional architecture also constitutes wholly kitsch examples.

The idea of ecological tourism in Turkey presents an opportunity that guarantees continuity of traditional building pattern, sustainability of local life and economy for small-scale vernacular settlements. First of all, it enables the visitors to introduce with the local cultures explicitly. This causes the inhabitants to possess their living environment while they carry out the economical sustainability of the settlement. Therefore, eco-tourism in Turkey should need more encouragement due to sustain the rural built environment.

3.2. Sustainable Architecture in Turkey by Governmental Efforts

3.2.1. Experimental Energy-Conscious Buildings: Experimental energy-conscious buildings are the limited number of sustainable examples in Turkey funded by the central

governmental boards. They are designed and constructed by public institutions, especially universities and research centres of Turkey.

Energy crisis of early 1970's in Turkey directed many researches to be carried on renewable energy sources and their utilization in buildings. Since most widely found renewal energy form in Turkey is the solar energy, the experiments were concentrated mostly on its utilization. Thus, the experimental solar houses have been built in various locations of Turkey since 1974. The refreshing interest to environmental crisis at the last decade enlarged the scope of researches on clean and renewable energy sources and their operation in energy-conscious buildings. The buildings are designed to apply the passive and active way of heating, cooling and ventilation applications and to minimize energy consumption and costs in buildings. These are the experimental houses of MTA Solar Energy Laboratory, Çukurova University Solar House, Ege University Solar Energy Institute, Ankara Municipality Solar House, Middle East Technical University Solar House (Fig. 11) (Demirbilek, 1999), Erciyes University Solar House, Erciyes University Sports Hall (Fig. 12) (Tekin, 2001) and Hacettepe University Solar House.

The number and distribution of experimental buildings in Turkey indicate that the encouragement of researches on energy-conscious buildings is insufficient. The local governmental organizations and universities do not have any policy to support sustainable building, as parallel to the interest of central governmental boards on sustainable architecture.

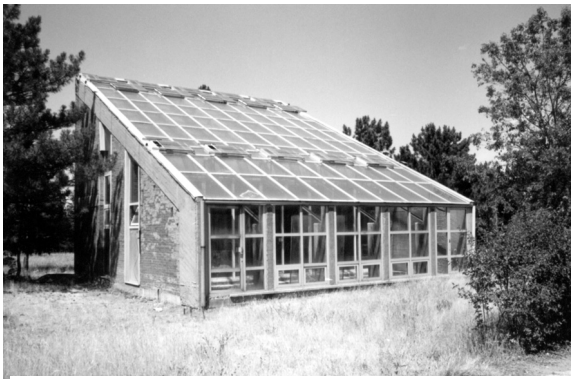

Fig. 11. Middle East Technical University Solar House in Ankara (Photograph by Zeynep Arsan)



Fig. 12. Erciyes University Sports Hall in Kayseri (Photograph by Zeynep Arsan)

Most of experimental energy-conscious buildings are open to discussion in terms of their

architectural quality. Because the teams composed of engineers excluding the architects designed some of them, they have poor representation of spatial quality and lack of zeitgeist. Moreover, the building materials and construction system, that is generally reinforced concrete skeleton system as being the most spread building construction system in Turkey, have been chosen far from any ecological point of view. The relationship with the local built environment and social values is also insensitive. As a consequence, it is hard to evaluate these various buildings of research groups as a design product or not.

3.2.2. Köykent Project: Köykent Project is a kind of rural development program in the scope of rural sustainability coordinated by Ministry of Housing and Public Works, Central Governmental Institution. It is a large-scale project to make plans of alternative rural environments, projecting the sustainability of rural life within the perspective of betterment of life expectations. Projects are based on the network of new self-sustaining villages, which have agricultural economical system in different rural regions of Turkey.

Köykent project is planned as a "precaution scheme" against the large scale of migration from rural to urban areas in Turkey (Gülçubuk, 2001; 10). To stop the immigration to cities because of insufficient supply of services and lack of job opportunities in rural regions is the first aim of this project. Secondly, they encourage the return of immigrants to rural areas in which inhabitants have better occupations, infrastructure and life expectations. Therefore, the settlements are constructed for both the villagers of the rural regions and the immigrants living in worse conditions in cities. They give opportunities for the continuity of economic growth and sustainability of current social life against the deterioration of cultural values seen in cities.

The program anticipates gathering the potentials of group of villages, forming co-operations for the development process. At the same time, it facilitates the governmental services to broaden through the rural areas of Turkey (http://www.arkitera.com/haberler/2002/01/26/koykent.htm).

A pilot project continues in Mesudiye, Ordu, supported by World Bank's loan for rural development projects (Gülçubuk, 2002). In the scope of the project, 9 villages of Mesudiye district coordinated their possibilities and power to constitute a confederation with their infrastructure, water network, social and cultural centres and roads. The local government fulfilled the public requirements, i.e. school, hospital or fabric, in one of the districts instead of performed separately for all ones. Villagers of Mesudiye maintain the program from the beginning of this project.

This project advocates the self-sustainability of rural settlements. On the contrary to this basic theme, it undervalues the ecological point of view within both social structure and built environment. The project does not notice ecologically sound alternatives to planning and construction of a settlement. In the scope of affordable housing, the new buildings are constructed as a skeleton system with reinforcement without using traditional construction techniques. The production of energy and the use of renewable energy sources are not still considered. Recycle of organic wastes on a community level is also out of question. In this respect, the architectural proposals cannot be regarded as wholly sustainable buildings.

Actually, it is contradictory that the governmental boards sustains the idea of rural development by Köykent Project, while it has no any formal national policy based on

sustainable ruralization. Even if this project serves for decreasing migration, there is a reality that is the unavoidability from city life and migration through urban settlements. The project proposes a romantic view of purely pastoral life style versus the pressure of industrial improvements in cities. It cannot serve alternative solutions to the paradox created by the occupation of rural areas by urban citizens, while the population growth derived from this kind of rural people in cities. It can be concluded that the project should reconsider the development program in terms of social, ecological and economical aspects of sustainability in Turkey.

4.CONCLUSION

Sustainable buildings of Turkey specify the unique position about the concept of sustainability belonging exclusively to Turkey. First of all, the examples provide us different models to build up new practices, since they reflect varied regional conditions and priorities in material, building and settlement scales. Even if some are fairly imitations representing imported discourse on sustainability of western world, the other buildings are the authentic ones signifying contextualist approach based on local sustainability. Therefore, the limited number of sustainable buildings constitutes samples to present better solutions and design tools for new buildings in Turkey.

The fundamental approach for design and construction of new sustainable buildings in Turkey should be to consider the economical, social and ecological peculiarities of the country contemplating the fact that Turkey is a developing nation. This inevitable outlook should be achieved with the help of governmental involvement as much as the concern of non-governmental organizations. On the contrary, only several projects so far have been encouraged or directed by governmental boards. There is no valid architectural or planning policy promoting and supervising the sustainable production in Turkey. Consequently, there is an urgent need for an active governmental involvement in establishing sustainable human environment.

Suppose the continuity of this state-of-art, it is better to determine various strategies for new sustainable solutions in Turkey. Further studies should concentrate more on the following aspects:

- The extra attention to urban sustainability issues in Turkey: There are a limited number of sustainable operations for urbanization in both urban design and city planning scales. Ecological regeneration and rehabilitation studies on urban form should be promoted due to the betterment of city life. Moreover, the importance should be given to co-housing projects in cities to stop the spread of private housing in rural areas and to minimize the ecological footprints in both agricultural and natural landscape.

- The more importance to rural sustainability: There is a limited number of projects respect for rural sustainability of small towns in Turkey. Sustainable building projects in rural areas should be supported in terms of stop the large-scale immigration through the urban settlements. Since the concept of sustainability concerns to form a sustainable life both in rural and urban areas while assuring social, ecological and economical sustainability, the new architectural practices in rural areas should be directed and supervised in terms of sustainability.

- The widespread trend in sustainable architecture of Turkey: The most common approach seen in sustainable examples of Turkey is to build new ecological private houses. The inhabitants of these houses migrate from cities to rural areas and then, cause to the spread of urban form. The damage on natural ecosystem should always be considered.

- The continuity of vernacular sustainable settlement: The lack of importance to conservation of current vernacular sustainable values constitutes the problem for local sustainability of settlements in Turkey. Builders should reconsider the traditional life cycle and building technologies of the region in terms of building form, location, settlement pattern, street-building relations, building materials, connection details and some cultural properties.

- The encouragement of use of local materials: There is a rising interest to traditional craftsmanship and construction techniques within the use of local materials such as timber, stone, mud brick and brick in sustainable buildings of Turkey. The use of local materials and the continuity of traditional construction techniques should be the precept for the new sustainable buildings.
- The use of local and renewable energy sources in sustainable buildings: There is insufficient interest and use of renewable sources of energy in building industry of Turkey. Due to the geographic location, Turkey has an advantage for the utilisation of solar energy. The production of energy and the use of renewable energy sources, however, are not still considered properly. Especially the use of local energy sources produced independently in site should be an essential subject in terms of self-sustainability of settlements. The experiments on the passive and active way of heating, cooling and ventilation applications should be more encouraged by universities and non-governmental organizations. Minimization of energy consumption and costs in buildings might awaken the public interest to the subject.
- The lack of sustainable building industry in Turkey: Building industry is still no take up sustainability as part of mainstream business. The active governmental encouragement should be needed.

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A Norwegian Certification Scheme for Recycled Aggregate (RCA)

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1. INTRODUCTION

As a part of the Norwegian research project RESIBA, a certification scheme for recycled aggregate has been establised. RESIBA was a 3-yearly project supported by the Norwegian EcoBuild and was finalized spring 2002. The aim of the project as a whole was to formulate recommandations for areas of use of RCA, requirements for properties depending of the area of use and finally means of assuring the quality of RCA. Quality assurance of RCA was the main motivation for drawing up a certification scheme for RCA.

Besides beeing based on experience from practical applications of RCA in different areas of use, the work of RESIBA was based on ongoing work within the European Community. This especially applied to the development of European standards for aggregate. A simular Dutch certification scheme was also of imporetance in the work. Formal legislation concerning environmental issues was also considered working with the document.

The main aim and motivation for developing the certification scheme was to give users of RCA confidence to the material itself, especially concerning environmental aspects, but also concerning the importance of having properties with defined tolerances on variation througout a delivery.

As part of the work of the project it was also seen as important to classify RCA. This classification of recycled aggregate is stated in an Appendix to this document.

2. PRODUCTION CONTROL SYSTEM

As in the forthcoming harmonized European Standards for aggregate this scheme for recycled aggregate is based on a requirement to the production control system of the producer. All basic elements of this system should be described by means of a Quality Manual. The manual should describe or comprise all established and implemented procedures and instructions concerning the production of recycled aggregate.

Furthermore it must be described how maintenance of the manual are taken care of, the handling of non-conforming products and corrective actions taken, the authority and responsability for leading personell, the training and education of personell, the established control plans and final documentation and filing of documents.

3. INSPECTION OF BUILDING MATERIALS UPON RECEIPT

To have confidence in the final RCA products with respect to dangerous substances and thus to avoid extensive testing of the final product, it has been seen as vital to have necessary knowledge of the construction and demolition material to be recycled. Ideally the best way to ensure this would have been to require pre-evalution of the construction and demolition materials with respect to both dangerous substances and contaminations before transport to the producer of RCA.

In some Norwegian communities local legislation require both pre-evaluation of the construction and a demolition plan based on this pre-evalutaion. These documents are publicly available and thus they will be of importance to the producer of RCA. For use in concrete the Publication no. 26 from the Norwegian Concrete Association also require a special pre-evalutaion of the conctruction with respect to possible contamination of special importance for re-use in concrete. As the Norwegian legislation in general so far do not require this, it has however been necessary to find alternative ways to ensure knowledge on the building materials reveiced at the production site.

Because of the situation in Norway both regarding the legislation but so far also with respect to how demolition material are delivered to the producer of RCA, with normally no documentation accompanying the delivery, the suggested certification scheme requires the producer to have established procedures concerning the receipt of demolition material. The documentation established through these procedures should indicate the type of material, the origin of the material, the transporting agent, possible contaminants and if relevant corresponding results from pre-analyses of the construction and/or demolition material. It is also required that personell responsible for reception inspection are specially trained for this job and that this training are documented. Finally it is also required a certain testing of the RCA products to ensure the quality, see table 1 of this document.

4. PRODUCTION AND TESTING OF RCA PRODUCTS

The production itself should be managed by means of the established and implemented procedures, routines and instructions. In addition the results from the testing of the final products are considered to be an important input as to the management of the production. It is considered as vital that the producer has a certain minimum of laboratory equipment either on site or nearby. This to be able to make use of the results to manage the production. It is also required that laboratory personell have undergone training and that all equipment are maintained, checked and calibrated according to established procedures and standards in forth.

Testing of final products shall be carried out at the minimum frequency required in table 1. The given minimum frequencies presumes a relatively continous production with even materials, otherwice the frequencies have to be increased. On the other hand the frequencies might be decreased if the producer document very stable product properties. This is to be done in agreement with the customer or the certification body.

Table 1 Test frequency for bound and unbound use

Property to be tested	Test	To be tested by	Test frequency at continuous production

	method	(type of lab.)	Products for bound use (for concrete)	Products for unbound use
Grading	EN 933-1	L [1)]	One per week or min. per 2000 tons	
Fines content (materials < 0,063 mm calculated on materials < 19 mm)	EN 933-1	L [1)]	One per week or min. per 2000 tons	
Content of materials < 0,020 mm calculated on materials < 19 mm		L [1)]	-	If required
Material composition	prEN 933-11	L [1)]	One per week or min. per 2000 tons	
Organic materials [5)]	EN 1744-1	L [1)]	One per week or min. per 3000 tons	-
Shape - Flakiness index (of materials > 8 mm)	EN 933-3	L/C/E [2)]	One per month	
Mechanical properties (Los Angles)	EN 1097-2	L/C/E [2)]	-	One per two weeks or min. per 10 000 tons
Density	EN 1097-6	L/C/E [2)]	One per two weeks or min. per 10 000 tons	
Water absorpsion	EN 1097-6	L/C/E [2)]	One per two weeks or min. per 10 000 tons	
Chloride content [5)]	EN 1744-1	L/C/E [2)]	One per two weeks or min. per 10 000 tons	If required
Sulfur-containing compounds	EN 1744-1	L/C/E [2)]	If required	If required
Chemical analyses [4)] (Leaching test)	EN 1744-3	A [3)]	-	One per two weeks or min. per 10 000 tons

1) Should be tested at the production site to be able to manage the production on basis of the test results
2) Might be tested either locally, at a central laboratory or external
3) To be tested either at a third party approved or accredited laboratory
4) Alternative methods might be accepted
5) The test frequency might be reduced by 50 % if it is carried out pre-evaluation of the building according to Publication no. 26 from the Norwegian Concrete Association

5. DOCUMENTATION OF THE RCA PROPERTIES

Based on experience from this production and the test results the producer shall work out a document of declared values for the requested properties dependent on the end use. This document shall also state within which tolerances or maximum/minimum levels the user can expect this material to be delivered. At the start of the project RESIBA it was aimed to fix these tolerances and limits as it had been done for natural aggregate. At the end of the project it was however considered that the number of results from the different practical projects were to low to fix these limits.

In the certification scheme it is stated the number of test results to be basis for the declared values. In cases where it is a need for revising one or more of the declared values the scheme also states the number of results to be basis for such a revision. Basically, all a user of recycled aggregate should need, is the data sheet with declared values and tolerances/limits from the producer.

During production and testing the producer is required to compare his test results with his declared values and limits given on the data sheet and act according to the outcome of such an evaluation. If he obtains results outside of what he has declared he is obliged to inform his customer.

6. CONCLUSIONS

The described certification scheme has been established as a voluntary certification scheme. It has been established with the aim to help increase the use of RCA and to give the user confidence in the product. It is recommended that the user require of his supplier of RCA that he is certified according to the requirements of the scheme. If not possible the user should at least use the scheme as an aid when drawing up specifications and requiring documentation for his delivery of RCA. It is also considered that the certification scheme will need to be amended and/or revised based both on experience with the scheme and the development on legislation nationally and standardization within the European Community. This work will be undertaken by Kontrollrådet for betongprodukter both as one of the participants in the project and as a certification body.

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The Norwegian Building Regulations 97

The Community of Oslo: Regulation concerning the management of production vaste

BRL 2506: Dutsch guideline for certification of RCA

RESIBA: Use of recycled aggregates – Status 2000

APPENDIX

Classification of recycled aggregate

The classification of recycled aggregate for bound (cement) use is based on Publication no. 26 from the Norwegian Concrete Association and the experiences from the RESIBA-project.

The given minimum frequencies for material composition for the following four types are general requirements. Depending on the end use of the recycled aggregate it will normally be necessary to add requirements concerning the properties of the recycled aggregate.

If nothing else is stated the percentages given in the table is to be calculated on mass.

	Type 1 "Crushed concrete"		**Type 2 "Mixed materials"**	
	A - Bound use	**B – Unbound use**	**A – Bound use**	**B – Unbound use**
Main materials :				
Crushed concrete and/or natural aggregate	> 94 %		-	
Crushed concrete, crushed masonry and natural aggregate			> 90 % [1)]	
Other granular materials :				
Crushed masonry	< 5 %	< 5 %	-	-
Crushed asphalt	< 1 %	< 5 %	< 1 %	< 5 %
Non-mineral contents :				
Wood, paper, metals, soft material[*)], organic materials[**)], plastics, glass, rubber, others	< 1 %		< 2,5 %	
[*)] Soft materials	< 0,1 v. % [2)]		< 0,5 v. % [2)]	
[**)] Organic materials	< 0,1 v. % [2)]		< 0,5 v. % [2)]	
Density – oven dry [3)]	> 2000 kg/m^3		> 1500 kg/m^3	
- water dense, surface dry [3)]	> 2100 kg/m^3		> 1800 kg/m^3	
Water absorpsion	< 10 %		< 20 %	

[1)] for end uses where it is laid down requirements to properties other than material compostition it is recommended to keep the percentage of concrete and/or natural aggregate at minimum 80

[2)] the percentage organic materials and isolation materials are to be calculated on volum

[3)] to be tested according to EN 1097-6. The requirement to be fulfilled by at least one of the methods.

Environmental and Resource Analysis of Urban Renewal in Xi'an, China – a Planning Tool.

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BACKGROUND AND AIMS

Building and construction activities put a great deal of strain on the global environment. Production and building processes, operation and maintenance throughout the life cycle of buildings, and demolition after use represent a high consumption of resources and a corresponding burden on the environment including emissions and waste. Hence there is a growing recognition that a consumer attitude is incompatible with future-oriented environmental management.

Repair and re-use of the existing built environment is often considered to be the most careful approach to urban renewal with regard to minimising environmental impacts. One objective of this project has therefore been to test if the theory of the combined aim of improving the living conditions, minimising the environmental impacts, and conservation, can be proved or made probable. To test this theory, we have developed a model for holistic assessment of the environmental impact of various urban renewal strategies. The model has been developed through comparative studies of different urban renewal strategies, applied to one urban renewal site within a study area in a major Chinese city. The model can also be applied to a neighbourhood or a part of a town.

The model will enable us to compare central resources and environmental indicators, including ecological environment factors, matters relating to the cultural environmental characteristics of the area and housing standard.

DEVELOPING THE MODEL

Figure 1 shows the stepwise procedure of using the model in the planning of urban renewal strategies. The different phases in the work are also elements in the model. The various steps are briefly described in the following. There may be overlaps between the different phases. Also, the process should not be a linear one; iterations will have to be carried out as new insight is gained throughout the process. This learning is in fact the most important result of using the model; much more important than the numbers that come out of the process. At the same time, the

system also facilitates that the learning and decisions of the process will be documented. This is particularly useful in public spending projects. (Andresen 2000)

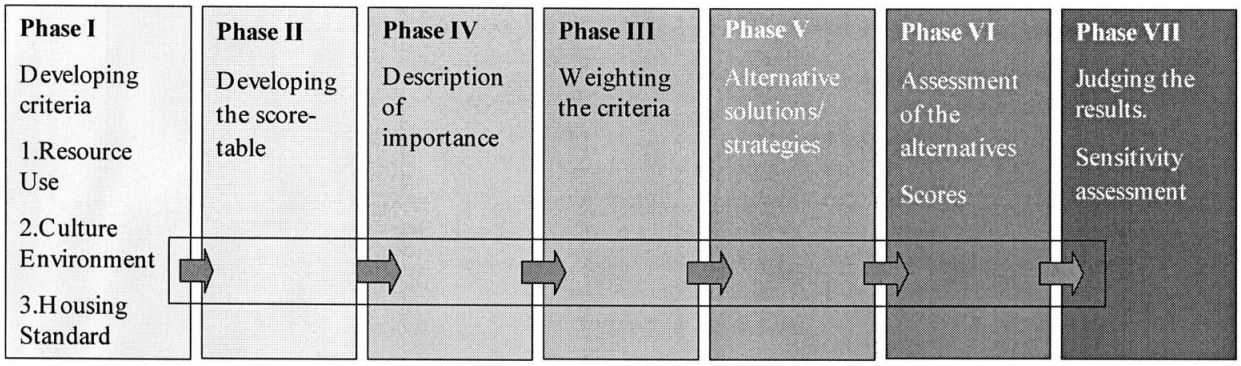


Figure 1: Model for assessment

DEVELOPING THE CRITERIA

Developing the criteria against which the urban renewal strategies are going to be measured, is probably the most important task of the process. The criteria will determine what issues are going to be discussed in the planning process, and they will determine the final choice of strategy. It is therefore recommended to start out wide with an exhaustive list of criteria, and then refine it by elimination. Specifying why the criteria are considered to be important, may be a useful tool in the elimination process. In order to get a manageable set of criteria, it is also recommended to group the criteria hierarchically, with the general, less specified criteria at the top, and the more specific criteria at the bottom.

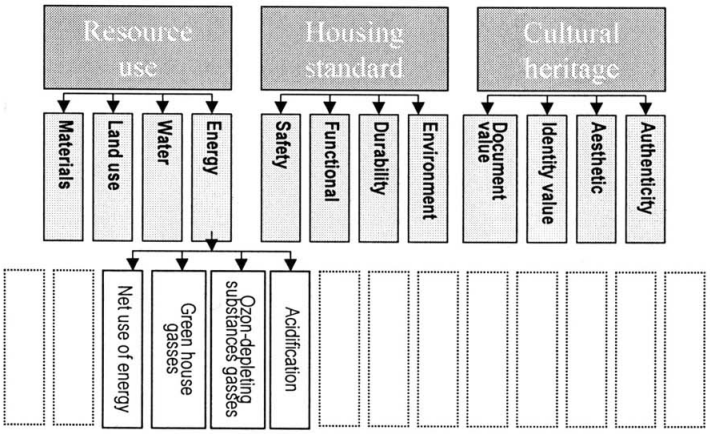


Figure 2 The criteria hierarchy

For the Xi'an project we have chosen criteria based on a view that an urban structure should be regarded in relation to the following main concepts:

- as an **ecological system**, which uses natural resources and represents a large or small burden on the environment with respect to construction and operation and demolition and renewal
- as a **living environment** for those residing in and using the area
- as an **expression of our culture and history**, and as a means of expressing cultural identity and a sense of belonging

In the context of urban renewal, all these types of resource are involved to one extent or another, depending on the strategy being pursued, which might span from complete replacement of the existing building environment to various degrees of intervention in the existing environment. Consequently, the following 3 main criteria have been included in the model: Resource use, Cultural heritage and Housing standard.

Environmental criteria

The criteria specified in the Green Building Challenge (GBC) project (Larsson and Cole 1998) have been used a basis for developing criteria in the Xi'an project. The environmental impacts of urban structures may be associated to the use of resources. Therefore, the environmental criteria may be structured under the 4 resource use criteria; use of energy, use of land, use of water, and use of materials, see table 1.

In the GBC framework, several of the environmental criteria require quantitative assessment. In the Xi'an project, and in most urban planning projects in practice, there is no time for extensive quantitative assessments, like for example the assessment of kg CO_2-emissions. Therefore, most of the criteria in the Xi'an project have been assessed based on a combination of quantitative calculations and qualitative judgements. For example, the energy use criterion has been assessed based on key data for embodied energy for the most energy intensive materials, and a rough calculation of the heating energy use (according to Chinese Industrial standard JGJ-26-95). Energy for cooling, lighting and equipment are assumed to be equal in all three cases, thus the assessment of these numbers is not needed.

1.	**Resource Use**		
1.1	Energy		
1.1.1	*Net use of energy*		
1.1.2	*Emission of greenhouse gasses*		
1.1.3	*Emission of ozone-depleting substances*	1.4	Materials
1.1.4	*Emission of gasses leading to acidification*	*1.4.1*	*Retention of existing building for new uses*
1.2	Land Use	*1.4.2*	*Use of materials that are salvaged or have high recycling content*
1.2.1	*Net area of land consumed for building and related works*	*1.4.3*	*Amount of materials predicted to be re-usable*
1.2.2	*Change in ecological value of site*	*1.4.4*	*Amount of materials predicted to be re-cyclable*
1.3	Water	*1.4.5*	*Amount of materials that are scarce*
1.3.1	*Net annual consumption of water from building construction and operations*		
1.3.2	*Emissions of water / pollution of water*		

Table 1. Selection of criteria. Resource use

Criteria for housing standard.

Housing standard has to be related to what is normal in the society and what is expected to be normal in the near future. The existing standard of the Drum Tower district in Xi´an is relatively low, so the model has to be based on or related to the present, national housing standard of China.

The criteria which are selected, are estimated to cover the most essential aspects of housing quality, classified in four, main groups: Functionality, safety, durability and environmental issues. The importance of the different issues is expressed for each sub-criterion. As in the other main criteria groups, there has to be a combination of quantitative and qualitative criteria. Most

quantitative criteria are easy to measure, (sq.m. housing area per person, rooms per family, sq.m. bicycle parking per family, and so on). Most qualitative criteria are easy to assess as well, (generality of space, accessibility, security and control, and so on).

Of the 22 sub-criteria half of them should be assessed by subjective estimation. For some of those it would be of importance to engage different groups of weighting the criteria, knowing that residents, professionals and politicians may have rather different views on quality and priority.

2.	**Housing**	*2.2.2*	*Fire safety and emergency exit*
2.1	Functional standard	*2.2.3*	*Security and control*
2.1.1	*Housing area*	2.3	Durability
2.1.2	*Room standard*	*2.3.1*	*Building construction*
2.1.3	*Private and semi-private outdoor space*	*2.3.2*	*Materials*
2.1.4	*The functionality of space*	*2.3.3*	*Equipment and facilities (water supply and sewage system, wire, etc.)*
2.1.5	*The generality of space (Diverse use of space, room by room)*	2.4	Environment
2.1.6	*The flexibility of space*	*2.4.1*	*Public outdoor space standard*
2.1.7	*Accessibility*	*2.4.2*	*Vegetation*
2.1.8	*Indoor air standard*	*2.4.3*	*Bicycle parking*
2.1.9	*Sanitary and infrastructure standard*	*2.4.4*	*Solid waste*
2.1.10	*Space for storage*	*2.4.5*	*Daylight and sunlight standard*
2.2	Safety	*2.4.6*	*Room standard*
2.2.1	*Structural stability*	*2.4.7*	*Room standard*

Table 2. Selection of criteria. Housing standard

Criteria for cultural heritage

As heritage values are defined as an integral part of the contemporary concept of environment, such criteria should be included in comprehensive environmental assessments of built environments. The question of how to measure heritage values has always been subject to discussions ever since conservation of buildings and objects became a task in itself. While age, rarity and aesthetic/artistic values previously were considered most important; assessment of heritage value is today based on a much wider set of criteria. Ability to contribute to cultural identity and continuity are examples of "modern" heritage criteria. How to measure qualitative heritage criteria in a meaningful way has been a challenge for the project. In order to assess the heritage values, four main criteria are defined: Identity values, document values, authenticity and aesthetic values.

During the project, a list of criteria based on experience on assessment of heritage values has been worked out and adapted to the model.

3.	**Cultural heritage**	*3.2.4*	*Representation / rarity*
3.1	Identity values	3.3	Authenticity
3.1.1	*Cultural continuity*	*3.3.1*	*Authenticity in design*
3.1.2	*Symbolic value*	*3.3.2*	*Authenticity in materials*
3.1.3	*Diversity value*	*3.3.3*	*Authenticity in workmanship*
3.2	Document values	*3.3.4*	*Authenticity in setting*
3.2.1	*Historic source value*	3.4	Aesthetic values
3.2.2	*Pedagogical value*	*3.4.1*	*Architectural / artistic value/design*
3.2.3	*Age value*	*3.4.2*	*Environmental value*

Table 3. Selection of criteria. Cultural heritage.

Developing a performance scale

For each criterion we have developed a scale where different solutions are to be assessed. Each sub-criterion has a performance scale. A performance scale is a way to convert a value into a score. A value can be a number or a phrase, depending on whether the criterion is quantitative or qualitative. Quantitative values are used for criteria that can be measured directly with numbers, such as annual energy use or carbon emissions. Qualitative values are words or phrases that can be used to characterize how well a building scheme rates against a particular criteria where the rating is more a matter of judgment, not normally subject to quantification.

The scale ranges from –1 to 6, where 1 is the benchmark level. A benchmark level has been established to indicate a national or a regional standard or an acceptable level. This scale has been chosen because it is easy to grasp; a negative number or a 0 represents a step in the "wrong direction", while numbers greater than 1 represents steps in the direction we want to go.

	1.4.3 Amount of materials predicted to be re-usable:
Score	Performance
	Based on judgements of their quality, accessibility and jointing:
-1	None of the building materials, components and systems has been consciously designed for recovery and reuse
0	
1	15% of the cost of the building materials, components and systems has been consciously designed for recovery and reuse
2	30% of the cost of the building materials, components and systems has been consciously designed for recovery and reuse
3	45% of the cost of the building materials, components and systems has been consciously designed for recovery and reuse
4	60% of the cost of the building materials, components and systems has been consciously designed for recovery and reuse
5	75% of the cost of the building materials, components and systems has been consciously designed for recovery and reuse
6	90% of the cost of the building materials, components and systems has been consciously designed for recovery and reuse

Table 4: Example of a performance scale.

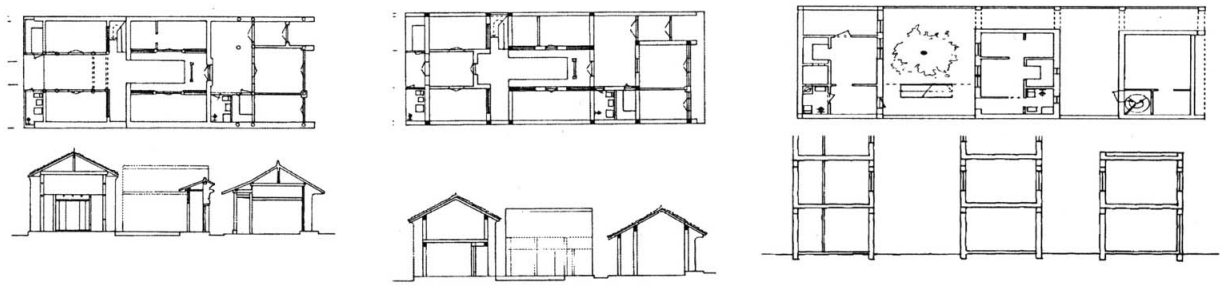
Weighting the criteria

Many of the criteria should be assessed by subjective estimation. For some of those it would be of importance to engage different groups of weighting the criteria, knowing that residents, professionals and politicians may have rather different views on quality and priority. All together we have 47 criteria in the model. But they are not equal considering the importance. Weighting the criteria is a question of taking a stand on different values and that is a task for the politicians in the decision making process. On the other hand the politicians need good advice from the experts especially when the more specific criteria shall be assessed. The weighting process is therefore a shared task between the politicians and the expert.

CASE STUDIES

In the study area we have conducted comparative studies for three different approaches to urban renewal:

1. Based on a preservation aspect
2. Mainly based on considerations of improving the housing standard and retaining the traditional architectural (courtyard house) design.
3. "Unrestricted" building without any particular environmental aims except the aim of high exploitation



Alt.1 Alt.2 Alt.3

Figure 3: Alternatives: Alt. 1 Preservation. Alt. 2 New court-yard-building, Alt. 3: New building with high exploitation

DOCUMENTATION AND SCORE

Through a comprehensive assessment of the three alternatives and documentation of the characteristics and consequences, we will get a score for each criterion in relation to the performance scale. In the assessment of these consequences we use different approaches and methods, from a system analytic calculation to a subjective estimate. The score for each alternative is multiplied with the weight to get a result for each criterion and a profile for the alternative that can be a specific solution, a building or an urban development strategy.

1.4.3 Amount of materials predicted to be reusable		
	Score	**Documentation**
Alt. 1	6	Reusable materials correspond to about 90% of costs Bricks can be easily dismantled and reused due to use of lime Wood is relatively easy to dismantle and reuse Roof tiles are easy to reuse
Alt. 2	1	Reusable materials correspond to about 15% of the cost – needs to be checked. OK Bricks cannot be easily reused due to use of cement. However, they can be used for lower quality constructions (e.g. animal shelters). Concrete constructions cannot be reused Roof tiles can be re-used Concrete floors can be re-used?
Alt. 3	2	Reusable materials correspond to about 30% of the cost – needs to be checked. OK Bricks cannot be easily reused due to us of cement. However, they can be used for lower quality constructions (e.g. animal shelters). Concrete constructions cannot be reused

Table 4: Example of documentation and score

RESULTS

Even if the weighting-process is a task for the politicians, we have set some preliminary weights in order to demonstrate how the model works. In a workshop in Xi'an in May 2002, we will discuss the model with the politicians, the residents, the authorities and experts in relevant professional fields. We will particularly look into the weighting system and discuss the use of the model and the results of the study.

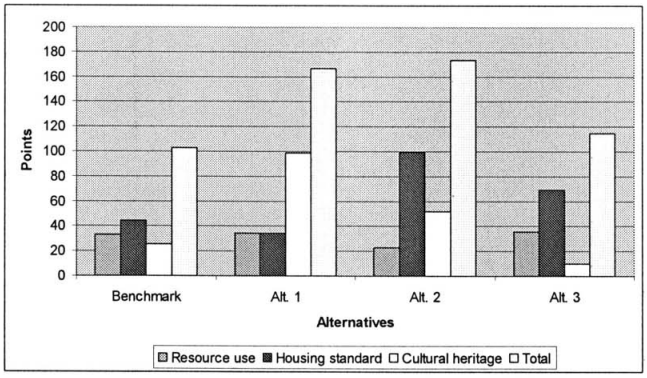


Figure 4: Example of results, comparing alt. 1, 2 and 3 with the benchmark level.

These preliminary figures demonstrate the results of the assessment and the comparison with the benchmark level for alt. 1, and a comparison of the 3 alternatives and the benchmark-level. From these figures it is easy to study how the different criteria affect different alternatives.

DISCUSSIONS ON USEFULNESS

Figure 4 shows how the assessment may give a result that demonstrates which alternative has the best performance according to environmental issues. This result is, however, depending on a set of conditions, subjective estimates and priorities. We believe that the most useful aspects of the model, is that it structures the discussion about performance criteria and values and it encourages the different experts to make their knowledge, judgements and values more explicit and open for discussion. In this way, the model promotes learning and understanding of the problem as a whole. Using the model, the decision making will be more transparent, which makes it easy to look into which arguments that are emphasised.

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Utilization of municipal solid waste incinerator fly ashes to produce cellular mortars

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1. INTRODUCTION

Cellular mortars are produced mixing very fine siliceous sand, cement, lime, anhydrite, aluminum powder and water in weight proportion 40%, 9%, 9%, 1.5%, 0.5% and 40% respectively. Once the mass has been molded and sets, it is cured in autoclave. This curing with high pressure steam avoids excessive shrinkage of the mortar.

Typical density of cellular mortars is 400-800 kg/m^{3}and compressive strength between 3 and 10 N/mm^2. Low density and low thermal conductivity makes the main application of this material to be in external walls and roofing. These properties are achieved by the reaction between aluminum and lime, releasing hydrogen that generates pores in the fresh mass. Some municipal incinerator fly ashes could be used to produce cellular mortars, because in particular cases may contain aluminum, lime, sand and anhydrite. This paper presents the results of the mix design process carried out to produce a cellular mortar using as majority component a municipal incinerator fly ash.

2. MATERIALS

The fly ash used in this study came from a municipal incinerator with previous recycling system and fluid sand furnace. Table 1 shows the results of the chemical and physical characterization of the fly ash.

Table 1 Physical and Chemical characterization of the fly ash

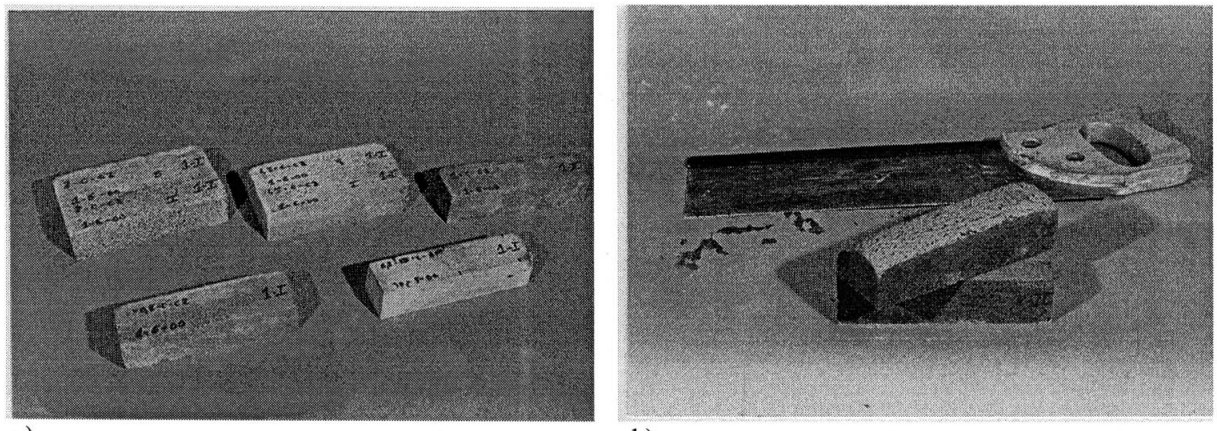
Sieve (mm)	%		
5.0	100	P.F. (%)	2.52
2.5	100	Cl^- (%)	2.60
1.25	100	SO_3 (%)	2.94
0.63	100	SiO_2 (%)	22.92
0.32	96.8	CaO (%)	21.79
0.16	77.9	Al_2O_3 (%)	23.83
0.08	43.8	Fe_2O_3 (%)	17.59
Density g/cm^3	2.83	MgO (%)	1.97
		Na_2O (%)	2.49
		K_2O (%)	1.74
Fineness 45 μm (%)	88.4	SiO_2 (%)	10.06
		CaO free (%)	0.80

Results of X-ray diffraction detected the presence of aluminum, anhydrite, quartz, calcite and portlandite, among others. The fly ash had no pozzolanic activity, as SiO_2 content came from the quartz of the sand used in the furnace.

3.- TEST PROGRAMME

The objective of the experimental programme was to find a mixture with density and compressive strength in the range of typical cellular mortars. Mixtures with different amounts of the components were tested: Sand from 0% to 50%, fly ash from 0% to 30%, water from 27% to 60% (percentages of mortar volume). In some mixes, lime was added in the same weight proportion of the cement. Mortars were mixed and tested for compressive strength according to EN 196 at 28 days of age.

Consistency of the mix was controlled with the shake table test. Some of the mixes exhibited a very fluid consistency not measurable, so they were described as "liquid consistency". Over the moulds lateral walls were placed to contain the expansive mass. Final volume after the expansion, was more than twice the initial one for some mixes (Figure 1a). Specimens were stripped at 24 hours, and kept in water (20±2ºC). Those mixes with lime were kept in humidity chamber (20±2ºC, 95%). At the age of compressive strength test, specimens with high expansion were cut as can be seen in Figure 1b.



a) b)

Figure 1 a) Specimens with different expansions; b) cutting before compressive strength testing.

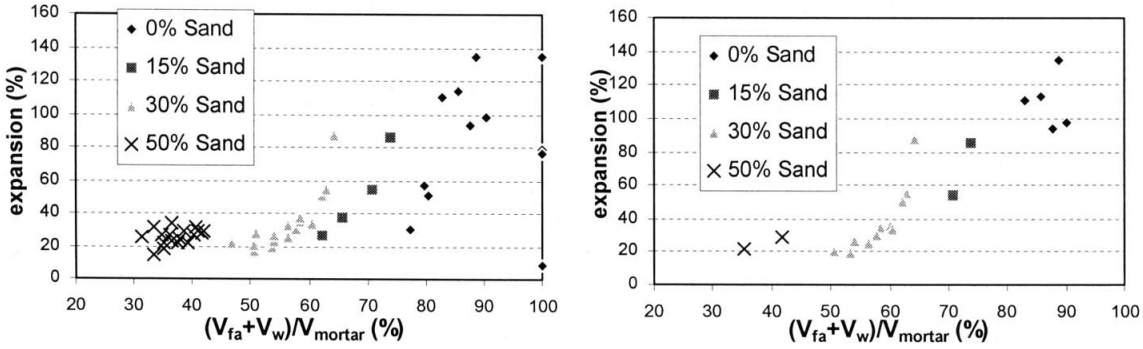
4.- STUDY OF THE EXPANSION

The expansion of the fresh mass must be maximum in order to obtain cellular mortars with very low density. In this chapter factors that influence on the expansion are described.

4.1 Expansive components

Sand, as an inert element, is the unique component of the mix that clearly does not collaborate with the expansion. Figure 2a) shows the increment of volume obtained with different amounts of sand in the mix. The expansion increases as the amount of sand in the mix decreases.

Also, in each sequence of results (same sand content), it can be observed that the expansion is higher as the content of fly ash and water increases. These means that the other two components used in the mix (cement and lime) do not contribute to generate the expansion.



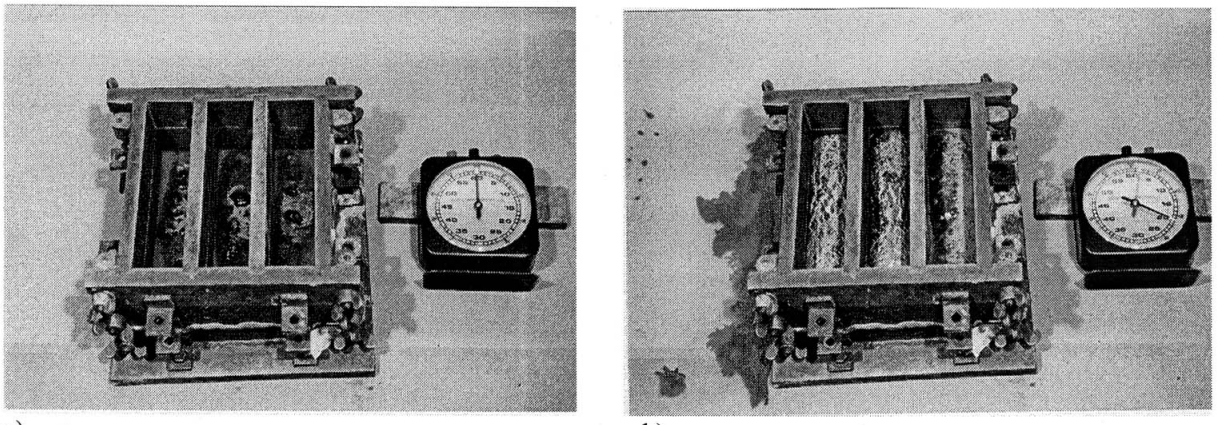
a) b)

Figure 2 a) Influence of fly ash + water in the expansion; b) only mixes with fluid consistency.

In deed, fly ashes are an auto-expansive material when mixed with water. Chemical reactions that produce the expansion are: $Al + NaOH + H_2O \rightarrow NaAlO_2 + 3/2\ H_2\uparrow$

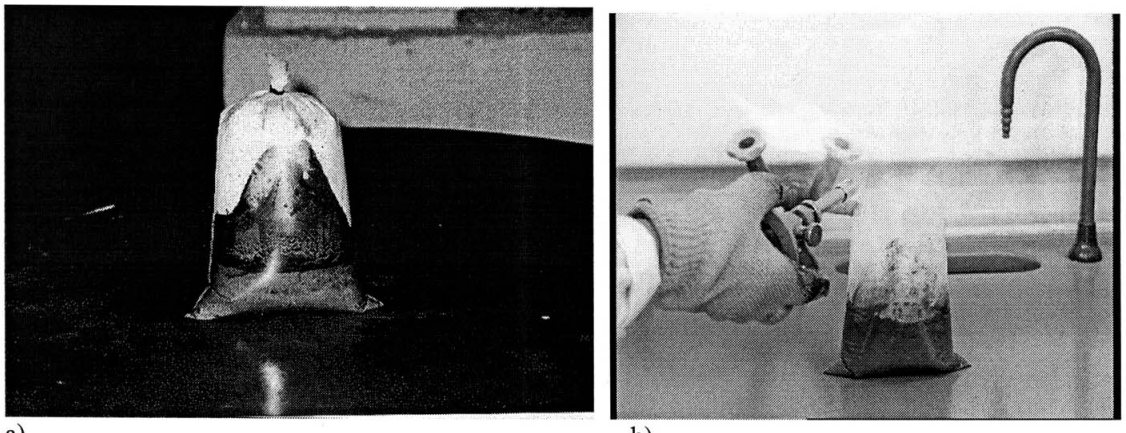
$$Al + KOH + H_2O \rightarrow KAlO_2 + 3/2\ H_2\uparrow$$

Metallic aluminum, Na_2O and K_2O are components of the fly ash, so only the addition of water is necessary. Hydrogen escapes from the fresh paste swelling the mass (Figure3). The release of hydrogen (inflammable gas) can be observed in Figure 4.



a) b)

Figure 3 a) Initial aspect of fly ash mortar; b) Final aspect after expansion takes place.



a) b)

Figure 4 a) The mix of water and fly ash releases hydrogen that inflates the bag; b) After cutting the bag, hydrogen can be inflamed.

4.2 Influence of the consistency

Results observed in Figure 2a) show that very different expansions can be obtained with the same content of expansive components (fly ash and water). These differences are due to a physical effect: the fresh mortar must have enough fluidity to allow the swelling when the gas escapes. A very stiff mass avoids the swelling. Figure 2b) selects only those mixes with fluid consistency (more than 170%), and the tendency to increase the expansion when the expansive components do is clear.

A big content of fly ash and water, and enough fluidity of the fresh mortar are the essential elements to get the minimum density.

5. STUDY OF THE COMPRESSIVE STRENGTH

Low density of the mortar must be accompanied of enough strength. In this chapter the influence on the strength of the different components of the mix is studied.

5.1 Influence of the fly ash content.

Figure 5 compares the water cement ratio curve of control mortars (no fly ash, no expansion) and curves obtained with different contents of fly ash. Only fly ash mortars with similar expansion (around 30%) have been selected, as this variable has an important effect on the compressive strength.

The compressive strength of fly ash mortars drops in low water cement ratios, consequence of the porosity created by the expansion. However, in high water cement ratios, there is an increase of strength in fly ash mortars, more when higher the fly ash content is.

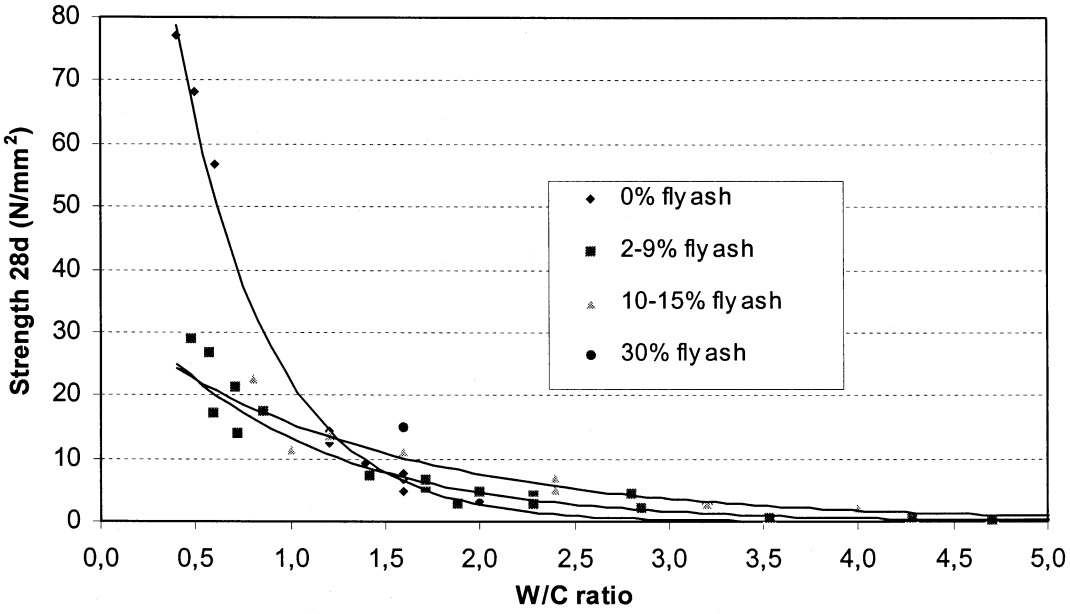


Figure 5 Water/cement curves for mortars with different fly ash content (mixes with 30% of expansion)

This means that fly ash improves the strength of mortars, and can even compensate the reduction due to the expansion in mixes with high water cement ratios. The origin of this contribution is the presence in the fly ash of some hydraulic components [4]: $2CaO.SiO_2$ and $3CaO\ Al_2O_3$.

5.2 Influence of lime

Figure 6 compares the strength results of mortars with and without lime. Between brackets there can be seen the corresponding expansion of the mix. Mortars with lime (even those with more expansion) reach higher strength than those without lime, for the same water/cement ratio. The mortar series with w/c = 1.6 shows the positive influence of the presence of lime on the strength and also the negative influence of the expansion on the strength.

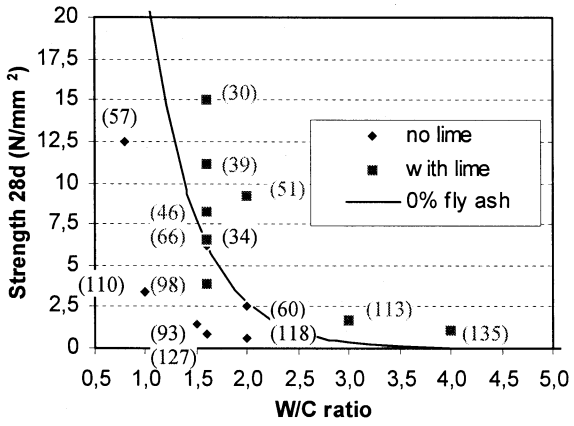
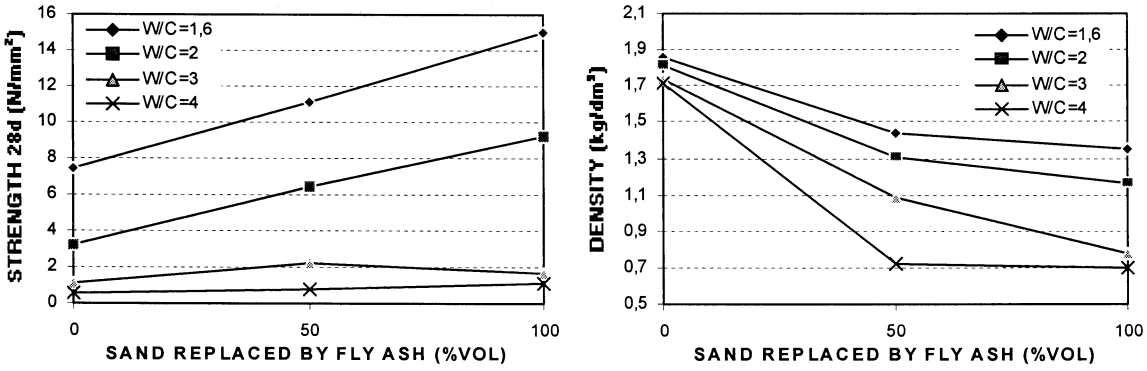


Figure 6 Influence of lime in strength. Values of expansion are shown between brackets.

5.3 Influence of sand

The best effect on strength and expansion simultaneously is obtained when sand is completely replaced by fly ash. Figure 7 shows results of strength and density in mortars with different substitution of sand by fly ash. Important increments of strength can be achieved, accompanied by an increase of expansion and so a low density, specially in mixes with not a very high w/c ratio.



a) b)

Figure 7 Influence of sand replacement by fly ash in the strength and density.

6.- FINAL ANALYSIS OF RESULTS

Table 2 summarizes the most relevant mixes in the process to obtain fly ash mortars with similar properties of the traditional cellular mortars:

1.- Complete substitution of sand by fly ash in the mortar achieves an important increase of strength, but consistency is negatively affected, so a moderate expansion is obtained.

2.- An increment in the water content, and so the cement content to maintain the w/c ratio allows a more fluid consistency that improves the expansion.
3.- More water is added with a better effect than in step 2.
4.- Partial replacement of lime by fly ash improves fluidity and also the expansion.
5.- An additional replacement of lime by fly ash increases even more the expansion, and a very low density is reached.
6.- The total elimination of lime is not recommended because of the substantial reduction of strength caused.

Table 2 Mix design process to achieve minimum density, and enough strength.

Nº	Cement (kg/m^3)	lime (kg/m^3)	Fly ash (kg/m^3)	w/c ratio	Fly ash vol.(%)	Consistency (%)	Expansion (%)	Density (kg/dm^3)	strength (N/mm^2)
0	296	296	0	1,60	0	90	0	1,64	5,3
1	296	296	801	1,60	30	60	30	1,18	11,8
2	316	296	696	1,60	26	100	39	1,09	8,5
3	341	296	570	1,60	21	120	46	1,02	5,7
4	341	236	641	1,60	24	145	66	0,88	4,4
5	341	149	745	1,60	28	149	98	0,74	3,3
6	340	0	922	1,60	35	L	127	0,67	0,85

7.- CONCLUSIONS

- Cellular mortars can be produced using municipal incinerator fly ashes as majority component.
- In these mortars fly ash and water are the expansive components.
- Mainly cement, but also the combination of fly ash and lime give the necessary strength.
- The mix design process has been detailed in the paper.
- Mortars with final dry density between 0.74 and 1.09 kg/dm^3 and strengths between 3.9 and 8.5 N/mm^2 have been obtained.

8.- FUTURE RESEARCH

There are technical and environmental aspects that must be covered in a future research:

- Mortars with lower density could be obtained introducing chemical admixtures in the mix.
- Other properties of these mortars must be studied: thermal conductivity, shrinkage, and effect of autoclave curing.
- Study on the leachates from the cellular mortar must be carried out.

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The consideration of ecological quality in the valuation and funding of buildings – a methodical overview

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1. INTRODUCTION AND GOAL

In recent years, obvious progress has been achieved in the development of methods and techniques describing and valuing ecological quality of buildings. Criteria, which consider the aspects of saving resources, environmental protection and health care, were elaborated and implemented. Therefore, results of ecological building appraisals in form of labels, certificates and "building passes/cards" are increasingly offered on the market. Nevertheless, so far, one has to mention, that in most cases there is only a small demand for the results of ecological valuation. The authors presume that the reason is the missing linkage between ecological quality of buildings on the one hand and building valuation and fixing of funding conditions on the other.

Economic interests influence the behaviour of the major actors in the real estate market. One can expect that the demand for a higher ecological quality and a comprehensible, reproducible description and valuation of ecological quality will increase if it is taken into account when valuing and fixing the funding conditions. Consequently, the progress and distribution of the methods describing and valuing ecological quality can be stimulated. This would support a process of further harmonization. The following article is a basic approach providing some methodical starting points for the integration of ecological quality in valuing buildings and determining financing conditions. National characteristics and rules for the valuation and financing of buildings will not be considered to allow a general perspective .

2. ECONOMIC EFFECTS OF GOOD QUALITY

Currently, the term quality is discussed in a multi-layered way. One frequently distinguishes between the quality of an object or product and the quality of projects, processes or procedures. Within this article, the term refers to objects as well as building structures. Characteristics having a direct effect on resource demand, environmental protection and health care during the life cycle of buildings determine "quality" in this sense.

The European Valuation Standard 2000 (EVS 2000) also lists and describes the tasks for appraising ecological quality. According to EVS environmental assessment is: „... a report prepared by technical specialists looking at all the environmental aspects of property or proposed development (environmental impact assessment). Typically this would involve sampling of soil for contaminations and consideration of the remedial work that might be necessary together with noise, traffic generation, visual impact etc. It may also be referred to as land quality statement. It would in appropriate circumstances be annexed to a valuation report." (EVS 2000, S. 304)
Below, table 1 discusses the question if and how far a good or in comparison to conventional buildings even better ecological quality can be considered economically.

Table 1 Economic effects of ecologic quality (author)

Characteristics of ecological quality	**Economic effects of good ecological quality**
Energy consumption during occupation	Lower operating costs/higher tenancy rates
Utilisation of rain water/rain water seepage	Lower operating costs/higher tenancy rates
Possibility of household waste separation	Lower operating costs/higher tenancy rates
Longevity of building components	Lower maintenance costs Reduced risk for rental reduction
Longevity of the building	Higher returns due to longer occupational life
Adaptability of the building Adaptability of the building technology	Higher returns due to longer occupational life Reduced risk of rental loss Greater chances for alternative usage
CO_2-emission during occupation	Trade of CO_2-certificates
Thermal comfort Acoustic comfort Visual comfort Quality of indoor-air	Higher rents due to better housing quality Reduced risk of rental loss Where applicable higher productivity of the user (industrial/commercial building)
Higher potential for dismantling	Lower costs for disassembly/ higher real estate value (land value)
Higher recycling potential	Lower disposal costs/higher real estate value (land value)

In principle, for extra-ecological quality within economic categories, the following possibilities are considered:

- A rise in "value" as consumers are prepared to pay more due to their grown environmental awareness and
  a rise in the value of benefit and comfort of the building
- A rise in "value" as future options in building valuation are integrated
- A reduction of "risk" when determining funding and insurance conditions as well as calculating risks (rental loss and utilisation risk, among other)

The following chapters analyses to what extent the different aspects of good ecological quality can be considered when appraising the market value or loan value, when determining the financing conditions according to the credit-worthiness of the borrower and when preparing a trade with CO_2-certificates.

3. POSSIBLE INTEGRATION WITHIN THE MARKET VALUE APPRAISAL

To estimate the current market value of sites and buildings (real estate), internationally, the cost approach, the investment method and the comparative method are used. In the following chapters, the analysis of a possible integration of ecological quality in appraisal methods concentrate on the building valuation.

3.1 Cost Approach

The valuation of buildings when using this method is based on a "net asset value" in the sense of reproduction costs (fictitious reconstruction value – in Germany "Normalherstellungskosten"). In order to determine a "real current value", one reduces the fictitious reconstruction value taking into account technical and economical depreciation. The discount factor for the technical and economic depreciation is estimated taking into account the age and the building repair. The factor for the financial depreciation is determined amongst other by considering the adaptability of the building for changing preferences (marketability). The cost approach is mainly used for owner-occupied single-family houses as well as for administration buildings, schools and hospitals. As valuation upon cost approach is not based on market-related data the obtained appraisal value has to be reviewed to market conditions. If necessary, revaluations and revisions have to be made.
Aspects of ecological appraisal can be taken into account in this approach

- by assessing reproduction costs of ecological components construction standards (e.g. in Germany the standard of façade insulation and the type of heating system are taken into account valuing the "net asset value").
- by developing depreciation factors for the difficulties of building adaptation conforming to today's preferences.

Concluding, it is suggested defining ecological characteristics that are to be considered in the "fictitious reconstruction costs" as well as to develop rules for valuing functionality and adaptability.

3.2 The Investment Method/Income Approach

The income approach is mainly used for appraising apartment buildings and commercial properties, mixed-use properties and special real estate. With the income approach, the property's market value is obtained by discounting the continuous, average, anticipated future cash income. It is based on the time-value of money. The cash flows equal the net income obtained by the gross income minus the operating expenses (e.g. for administration, utilities, maintenance).
The income approach can take into account aspects of ecological valuation

- by regarding lower energy costs (better energy-saving standards) and lower maintenance costs (selection of suitable products and constructions) as well as lower risk for rental losses (e.g. due to higher consumption value and living standards, higher marketability) within the operating expenses.
- by considering a possible higher rental rate (due to higher living standard) as well as additional incomes (e.g. due to trade with CO_2-certificates) within the cash flows.
- by considering a longer economic life (due to building flexibility and adaptability) and lower risks – in Anglo-Saxon countries this is expressed using the *ARY all risks yield* – (due to better environmental protection and health care) within the discount rate.

It is suggested going over from appraising operating expenses grossly to a concrete valuation based upon the building characteristics.

3.3 Market Comparison Approach
(Direct Value Comparison Approach or Comparative Method)

The value is estimated after analysing sales prices of similar properties recently sold. The method is mainly used for appraising apartments and apartment buildings as many comparable transactions are realised in this sector. The properties are compared using special indicators. Possible differences are taken into account applying up- or downside factors. Typical indicators used up to now are age, state of repair and furnishing.
The market comparison approach can take into account aspects of ecological quality

- integrating ecological characteristics within the standard-indicators for building valuation and valuation of comparables
- developing a system of up- and downside factors to integrate ecological quality.

Possible characteristics for up- and downside factors can be: energy efficiency (referred to as an energy code or energy certificate), the degree of sound proofing, thermal comfort and quality of indoor-air as well as the building functionality and adaptability evaluated upon standardized rules (e.g. GBC).

4. POSSIBLE IMPLEMENTATION IN THE LOAN VALUE APPRAISAL

The mortgage granted by a credit institution is determined by the building's market value. Mortgage lenders or state-certified, professional appraisers estimate the market value using the approaches described in chapter 3.

4.1 Loan Value

In order to determine the loan value credit, institutions make an institution-specific or collateral-specific security deduction (10-20 %) on the estimated market value. This depends on foreseeable risks as well as on the marketability of the collateral. The loan value is a subjective value. It takes into account either the risk-aversion of the lender or the individually different expectations of the market participants regarding the development of the collateral's market value. The discount rates for estimating the loan value do not regard current short-term market events but long-term market development.
(The concept "loan value" in mortgage finance is used to distinguish the open market values, a concept of the English Chartered Surveyors.
The loan value appraisal can take into account aspects of ecological quality

- by considering the reduced risks of the collateral within the safety discount. The "reduced risks" comprise lower marketability risks due to higher building flexibility/adaptability (real options) and higher expertise of all participants (planners, inhabitants, financial intermediaries etc.). To sum up, a higher loan value reduces the complete funding costs.

4.2 Loan-To-Value Ratio

The loan-to-value ratio is the portion of the amount lend by a credit institution in accordance with legal and institution-specific rules compared to the loan value. Different types of mortgages can be assembled in a funding package where mortgages are classified according to their risk. First-class covered mortgages have a loan-to-value ratio of 60% of the loan value. Consequently, the risk is mainly covered by the collateral and the credit institution is often not concerned about the borrower's credit solvency.
This is different for secondary mortgages. In Germany, they are usually granted up to 80% of the loan value. Subordinated mortgages are riskier having a claim in foreclosure only after

mortgages with higher priorities are satisfied. This fact is taken into account by a higher mortgage rate.
Estimating the loan-to-value ratio, aspects of ecological quality can be taken into account:

- (for primary mortgages) by raising the loan-to-value ratio according to lowered risks of the collateral
- (for secondary mortgages) as the borrower's solvency is broader due to a higher monthly disposable income (a result of the reduced energy and maintenance expenses) as well as higher marketability (rental income) and/or trade with CO_2-certificates. Consequently, lenders are able to offer more favourable funding rates on the one hand or borrowers can undertake higher investments on the other hand. (also review "Energy efficient mortgage"). In this context, it is also possible to think about new funding possibilities for credit institutions with mortgage-backed securities. All secondary mortgages could be gathered in a pool, optimally ranked due to the reduced solvency risk and offered on the secondary market. Therefore, the credit institutions could reach a more favourable funding that could be passed on to the borrower.

5. POSSIBILITIES OF THE OPTIONS THEORY

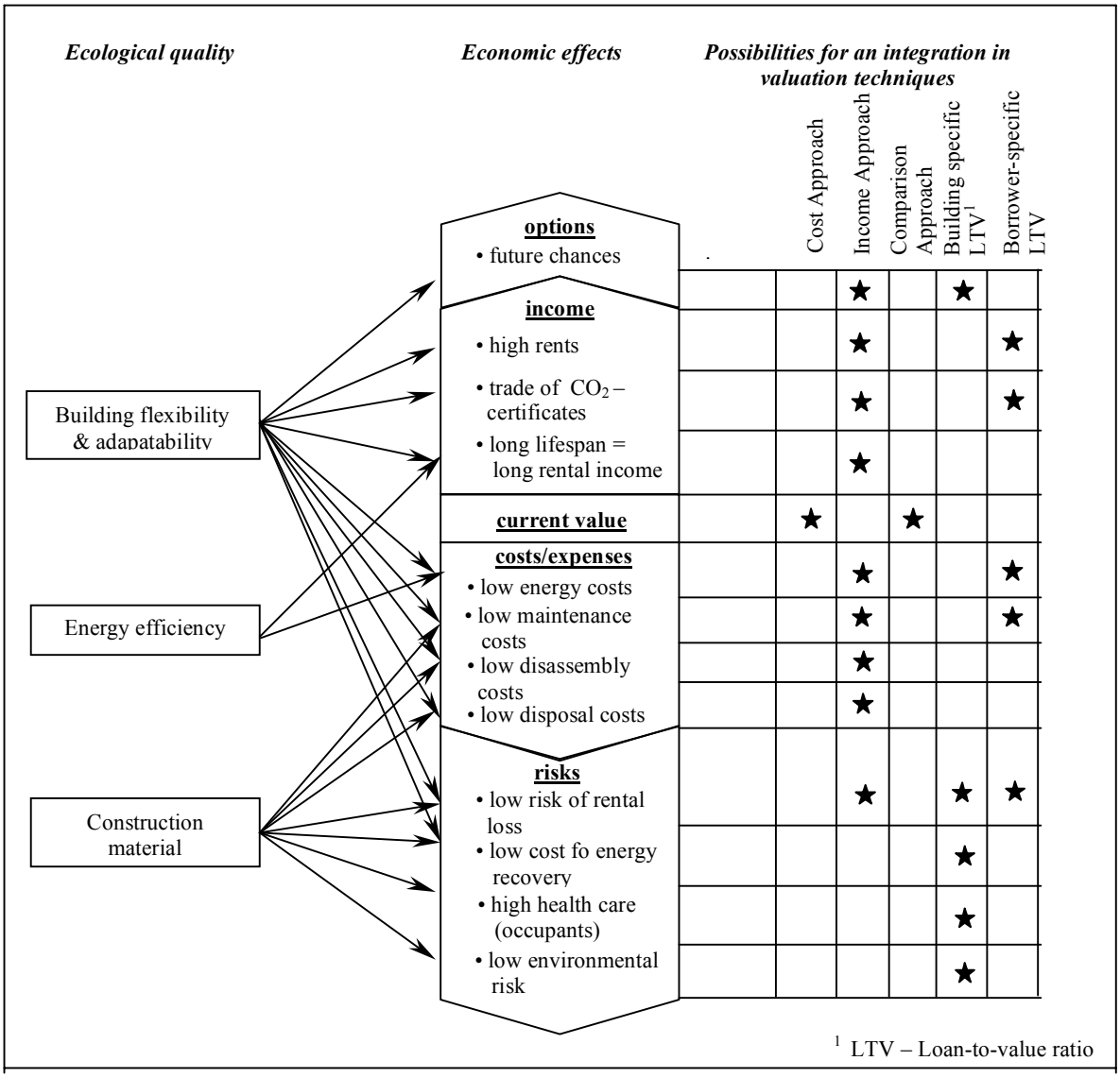
An important aspect of planning and construction sustainable buildings is to ensure the adaptability and flexibility when utilised. This is particularly important for office buildings and some special industrial buildings. A better building adaptability and flexibility raises its chance for further alternative utilisation. However, the appraisal methods discussed above can only partially consider these possibilities when estimating the building value. As they assume one particular utilisation they only appraise one scenario within the life cycle of a building. A possible way to analyse multiple scenarios during the utilisation period is applying (real)options theory. The option theory describes and values flexible alternatives during the lifespan of an investment project, which are consciously planned and often resulting in higher investment costs. Hitherto, the theory was only rarely used for valuing real estate except undeveloped sites. Nevertheless, one could think about regarding building adaptability and flexibility planned from the beginning as options that raise the building value. The building value is estimated by appraising the actual building state as well as the future alternatives and choices. However, there are also some difficulties in practical application of the theory itself, particularly when determining a risk-adjusted discount factor and estimating future cash flows. Nevertheless, the option theory delivers a methodically interesting approach for the description and appraisal of multiple/diverse scenarios, which occur reacting to varying demand.

6. CONCLUSION

The article showed that there are a number of approaches where ecological quality of buildings can be considered when valuing buildings and determining financing conditions – see also table 2.

The enumeration of possible ways for integrating ecological quality showed, that it works best for the investment method and the estimation of the borrower's solvency. As a result, a further development of these approaches in cooperation with the representatives of the financial intermediaries, appraisers and brokers is suggested. The authors welcome any contact or commentary.

Table 2: Correlation between ecological quality, economic effects and building valuation (authors)



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Sustainable Buildings in Australia: Challenges, Incentives and Successes

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1. INTRODUCTION

The earth's finite ecosystem is struggling to cope with the current level of human activity and consumption. Natural resources are becoming scarcer while consumers (people) are becoming increasingly more abundant. The current world population of 6 billion is predicted to increase by 50% to 9 billion by 2050 (USCB, 2002). Australia's current population of 19.5 million is predicted to increase by between 25% and 45% over the next 50 years (ABS, 2002). As a highly developed nation Australia has a duty to demonstrate how this growth can be achieved in a sustainable manner.

1.1 Climate change

There is new and stronger evidence that most of the global warming observed over the last 50 years is attributable to human activities (IPCC, 2001). The World Wildlife Fund (2001) has reported projections that much of the Great Barrier Reef, the world's largest living organism, could be destroyed by 2040 due to warming of ocean currents. Australia is currently the world's highest per capita emitter of greenhouse gases at 27.6 tonnes of CO_2-e per person per year compared to the USA at 21.1 tonnes and the European Union average of 10.3 tonnes (Turton et al, 2001).

The energy sector accounted for approximately 80% of Australia's net greenhouse emissions in 1999 (AGO, 2001), with energy use in residential and commercial buildings accounting for over 20% of the national total. By 2010 the emissions associated with commercial buildings are projected to increase by 94% compared to 1990 levels while those of residential buildings are projected to increase by 17% (AGO, 1999). If Australia ever ratifies the Kyoto Protocol it signed in 1998 then it will commit to limiting its emissions in 2010 to an 8% increase above 1990 levels.

1.2 Natural Resources

Forty per cent of Australia's forests have been cleared, and only about 25 per cent of the original forest estate in Australia remains relatively unaffected by clearing or harvesting (UNEP, 2000). In 2000, over 564,000 hectares of forest were cleared, giving Australia the sixth highest land clearing rate in the world (ACF, 2001). Three quarters of this occurred in Queensland. Intensive forestry practices are replacing original and old growth forests with regrowth forests that better meet the needs of the timber industry. This loss of forest quality is less obvious but also important as a threat to forest biodiversity.

Land clearing is also causing major dry land salinity problems with 17 million hectares of Australian farmland predicted to be affected by 2050, reducing productivity (ACF, 2001). Rising groundwater brings up ancient salt deposits which also affect urban areas causing

damage to building foundations and polluting water supplies. It is estimated that by 2020 Adelaide's drinking water supply will fail to meet world health standards for salinity.

Water is a precious commodity in Australia, the driest inhabited continent on earth, yet Australia has a greater domestic water consumption per capita than any other OECD nation (OECD, 1998). Over 60% of Australia's freshwater consumption is for domestic purposes. Domestic water metering, water efficiency labelling, the introduction of mandatory 6/3l dual flush toilets and extensive community education programs have helped slow the annual growth in consumption but further improvement is required to meet the demands of a growing population.

1.3 Waste

Australia generates more municipal waste per capita (776kg) than any other country (de Looper et al, 1998). This compares with the USA (730kg) and the European avearge of 430kg per capita (UNEP, 1999). EcoRecycle Victoria (2002) have reported that of the materials going to landfill in Victoria approximately 34% is construction and demolition waste. Of this 72% was from building demolition and 15% from building construction, 54.6% was clean excavated fill, 27.2% was concrete or brick and 7% was timber. Victoria has an extensive roadside recycling with approximately 25% of all domestic waste being seperated and recycled rather than sent to landfill.

2. SUCCESSES AND CHALLENGES

Many of Australia's remote communities, islands and resorts have sustainable design by necessity. With no access to grid electricity, mains water and town sewage systems they rely on stand alone power generation, water supply and sewage treatment. Consequently energy efficiency, solar power, rainwater harvesting, greywater systems and passive building design are commonplace to make best use of limited resources. *Couran Cove Resort* is a leading example of sustainability in remote locations (refer Section 7 for case study).

About 60% of Australia's population live in the five capital cities (40% in Melbourne and Sydney) where houses are relatively large, airconditioning is becoming standard and driveways are regularly hosed down. Office densities are typically 1 person every 20m^2 compared to 1 per 15m^2 in European cities. Quarry and landfill sites are abundant. Most urban buildings perform poorly when assessed against energy and environmental criteria. However, many recent projects have demonstrated the commercial viability of sustainable buildings in the residential, commercial and institutional sectors including:

- *Newington Village, Sydney* – a showcase residential development of over 2000 dwellings built for the Sydney 2000 Olympic Games (the so-called Green Games) which featured solar hot water, passive building design, careful material selection, water conservation and greywater systems and energy efficiency. It is also one of the world's largest solar powered suburbs with PV cells on 665 homes generating a total of 1000 MWh each year.
- *60l Green Building, Melbourne* – due to open in 2002 this 3300m^2 office building, a combination of new and refurbished construction, has been developed to demonstrate the financial viability of a sustainable commercial building. The building features passive design, natural ventilation, rainwater collection, on-site water and sewage treatment, landscaped roof garden and recycled and low impact materials. Tenants sign green leases and commit to operate their tenancy in accordance with an Environmental Management Plan. It will set new benchmarks for energy and water efficiency: predicted annual energy

consumption is under 50kWh/m^2 compared to a conventional building of 150kWh/m^2 and mains water consumption is reduced from 2400kl/year to less than 100kl/year.

Projects such as these are used to publicise and quantify the benefits of sustainable buildings to government, developers, property owners/managers, tenants, builders and designers. Changing the traditional approach to design, procurement and leasing is one of the significant challenges Australia needs to address if it is to improve its environmental performance in the building sector. The Federal Government, while providing some grants, rebates and education programs, is primarily relying on the industry to make most of the necessary improvements voluntarily.

Incentives are necessary to assist the building industry to *voluntarily* improve the sustainability of Australia's buildings for without them it will be business as usual. These incentives take the form of carrots (financial benefits) and sticks (legislation).

3. LEGISLATING IMPROVEMENTS

The Australian Building Codes Board and the Australian Greenhouse Office (AGO) are incorporating minimum mandatory energy efficiency measures into the Building Code of Australia (BCA) which will apply to all new residential buildings throughout Australia (categorised into 8 climatic zones). These measures will eliminate worst practice and encourage voluntary best-practise initiatives. There is speculation that a minimum five star energy rating will become mandatory for new residential and commercial buildings in the future. Meanwhile, State and Local Government, in the absence of stringent requirements in the BCA, are imposing ad hoc energy and environmental performance requirements for new buildings through local planning regulations. Examples include:

- The Victorian Government has introduced a minimum 4 star rating using the First Rate House Energy Rating Scheme for all new multi-unit dwellings (except houses) under four storeys.
- In the ACT all new houses must have a minimum ACT House Energy Rating of 4 stars and the ratings of new and existing houses must be displayed prior to any sale.
- The Docklands Authority in Melbourne has included minimum energy performance requirements for residential and commercial buildings in the A$5 – 10 billion Docklands precinct currently under development. The Docklands Authority has also developed its own ESD rating and certification system.

4. TAXES, LEVYS, REBATES & GRANTS

The rebates/grants to promote sustainability in Australian buildings are small when compared to the annual building market of $35-$40 billion. Examples include:

- **Photovoltaic Rebate Program –** A$31m program of cash subsidies for residential and community installations of PV cells and solar hot water systems.
- **Renewable Energy Commercialisation Program** – five year A$55m program for projects leading to the commercialisation of innovative renewable energy equipment, technologies, systems and processes. Building projects which have benefited from the program include:

  Melbourne Private University – A$755,000 for the design and development of Australia's first large-scale building-integrated photovoltaic (BIPV) solar system.

  120 Edward Street, Brisbane – A$740,000 for inclusion of an 80kW BIPV system in a 21 storey commercial high-rise building to demonstrate how advanced building

integration can reduce the cost of electricity produced from solar by up to 75%.

- **Living Cities Initiative**- A$50m from 1999 to 2002 to address urban environmental issues, such as air quality, urban waterways, waste management, chemical collection, urban vegetation and coastal water quality. Building project funding included:

  Kogarah Town Square – Urban Stormwater Initiative grant of A$629,000 for development of 220 residential apartments, commercial retail space, a public library and town square. Features stormwater filtration through a specially designed garden beds and rainwater collection for toilet flushing. The project also received A$1m for the establishment of a major building demonstration site for specific solar energy products and 200kW BIPV system under the RECP above.

Taxes influence prices and therefore behaviour, and can be used to discourage activities that damage the social or natural environment. There are potential environmental and social benefits in the steady shift of taxes away from labour and income and toward pollution, waste, resource exploitation and greenhouse emissions. In line with the tax shift philosophy the UK Government has introduced the Climate Change Levy and Aggregates Levy. Australia currently has no plans to introduce similar taxes.

Rosen (2001) reports that Australia currently subsidises renewable energy by about A$200million per year (refer examples above) while direct and indirect subsidies to the fossil fuel sector amount to about A$6 billion per annum. For new, sustainable technologies to compete there must be a level playing field.

The average domestic electricity tariff in Australia (based on 3300kWh.pa) is 16c/kWh. This compares to 20c/kWh in the UK, 23c/kWh in Germany, 15c/kWh in Norway and 10c/kWh in the US. In the UK electricity tariffs have decreased in real terms by 28% over the last ten years. TXU, an Australian electricity supplier and retailer, claim that the cost of generating electricity in Australia has increased by more than 50% from 2001 to 2002. In Victoria the state government has provided a rebate of A$118m to keep tariff increases from 15.5% in 2002 to a politically acceptable level of 4.7%. However Australian electricity prices will continue to increase over the next few years, with or without further subsidies, which will further encourage energy efficiency and renewable energy initiatives.

The Renewable Energy (Electricity) Act 2000 mandates that all Australian energy retailers and large buyers of electricity source an additional 2% of their energy usage from renewable sources on 1997 levels. As a result for every megawatt-hour (MWh) of electricity generated or displaced the owner of the renewable energy system can claim a Renewable Energy Certificate (REC). These RECs can then be sold to electricity retailers to assist in meeting their mandatory target. Dale (2001) reports that the current value of a REC is approximately A$24 but this is expected to rise to A$35 closer to the enforcement period of 2010.

5. ATTRACTING ETHICAL PROPERTY INVESTMENT

The US Social Investment Forum defines Socially Responsible Investing (SRI) as “an approach to investing that integrates personal values and societal concerns into the investment decision making process.” The Australian Managed Funds industry in 2001 was worth over A$700 billion with this expected to rise significantly over the next five years (Mays, 2001). In a recent study for one of Australia’s major banks, Westpac, over 69% or respondents indicated they would consider an SRI fund. SRI funds have consistently outperformed the All Ordinaries Index in Australia and equivalent market benchmarks overseas.

The Financial Services Reform Bill, introduced in Australia in 2001 requires the seller or issuer of investment products to disclose the extent to which labour standards or environmental, social, or ethical considerations were taken into account in the selection, retention and realisation of investments. This is therefore likely to lead to an increase in SRI funds. While the market for SRI managed funds is significant, the proportion of property in managed funds has halved in the last 10 years. If the Australian property industry is to attract more SRI fund investment it will need to improve its environmental and social performance.

6. BUILDING RATING SCHEMES

Labelling is a well established tool for conveying to consumers important credentials about products. Australia has well established labelling systems for energy efficiency of electrical appliances and water efficiency of showers, taps and appliances. There are now a number of building rating schemes operating or under development in Australia including:

- **House Energy Ratings** - a variety of simulation tools (eg NatHERS, First Rate) which determine the heating and cooling energy requirement of a house or apartment and give an energy rating of between 1 and 5 stars based on this.
- **Australian Building Greenhouse Rating** - the scheme benchmarks the greenhouse performance of commercial buildings or tenancies, giving them rankings of between 1 and 5 stars. It is based on the measured energy consumption of a building or tenancy over a 12 month period, normalised for number of staff, operating hours and climatic zone, and then converting this to greenhouse emissions. Purchasing green power from the electricity grid can be used to increase the star rating. The *NSW Police Headquarters* building in Parramatta is the first building in Australia to be developed with a ABGR contract requiring the finshed building to achieve a 4.5 star rating.
- **National Australian Building Environmental Rating Scheme (NABERS)** - currently being developed by Environment Australia the scheme is based on a star rating out of five for nine environmental performance categories.
- **Australian BREEAM** - the original scheme was launched in the UK in 1990 and is established as one of the world's leading environmental assessment tools for buildings. Sinclair Knight Merz is currently developing Australian versions of BREEAM and ECOHOMES in conjunction with the Building Research Establishment.

7. AUSTRALIAN CASE STUDY: COURAN COVE RESORT

The A$150m resort is set on 151ha of fragile and environmentally sensitive land on South Stradbroke Island in Queensland and manages its own water, wastewater, gas and electricity systems. It showcases super-efficient water and energy technologies and systems throughout.

A whole of system optimisation of site energy was undertaken in which every electrical appliance, pump, light and equipment was optimised and gas appliances were adopted where possible, including gas fired cappuccino machines and dishwashers. These measures reduced the electrical base load to 70% of that of a typical 5 star resort and led to the adoption of a 0.75MW gas power station compared to the industry norm 4MW diesel generator. The resulting capital cost savings were A$2.5million with operating cost savings of over A$1million per annum and greenhouse emissions reductions of approximately 7000 tonnes per annum.

The resort site was surveyed and audited by the Australian Conservation Foundation prior to construction. No mature trees were destroyed: the buildings and tracks were built around them. Common use services corridors were adopted throughout the resort with the aim of minimising disturbance to native vegetation. Treated effluent from the sewage treatment plant

is used to drip irrigate the resort's vegetation, sports oval and green fire break.

The conference/restaurant complex is built over the lagoon on timber piles recycled from old railway bridges. The exposed timber floors (and the boardwalks around the site) are constructed using plantation hardwood. The ecocabins are naturally ventilated and constructed with carefully selected timbers in 600mm modules to minimise construction waste. Low toxicity paints were used throughout the resort. Recycling bins are provided to all cabins. Biodegradeable waste is sent to the resort worm farm.

8. SUMMARY

Australia has developed many buildings which demonstrate the commercial benefit of sustainability. The challenge for the Australian building industry is to make these the norm rather than the exception. Legislation is being introduced to eliminate worst practice but more financial incentives will ultimately be necessary to encourage a voluntary change in building design, procurement and operation practices. These incentives will include government influence such as taxes or the reduction of subsidies to non-sustainable industries, the steady increase in ethical investment in sustainable property portfolios, and the increase in building valuation or marketability through energy and environmental labelling schemes.

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The Restricted Double Deck Method: A Sustainable Method to Increase Spatial Flexibility and Facilitate Pipe Repair Work in Apartment Buildings in Taiwan

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1. INTRODUCTION

1.1 Conventional Design and Construction Practices of Apartment Buildings in Taiwan

Apartment building accounts for the major portion of residential building stocks in metropolitan areas in Taiwan. Through decades of development, conventional design and construction practices of apartment buildings in Taiwan have formed. For examples, reinforced concrete is the most typical construction material used as the structural skeletons, and brick as interior partition walls, of apartment buildings; bathrooms are strictly located around the vertical plumbing shafts within individual apartment units; and water supply and wastewater pipes within bathroom are typically laid within walls or slabs (so called the conventional in-wall pipe distribution method, Figure 1).

1.2 The Post-Occupancy Problems

The conventional design and construction practices descried, however, have resulted in certain problems during the post-occupancy phase of apartment buildings in Taiwan:

1. 'Sustainability' problem: Since the standard layouts in newly built apartment buildings or the existing layouts in used apartment buildings may not be able to meet specific user needs, households who first move in would very often reconfigure the layouts of their units (tear down portions of brick walls). As a result, lots of unnecessary building wastes and environmental impacts were generated (Tu, 2000).
2. Lack of spatial flexibility: Since the locations of bathrooms and vertical plumbing shafts are fixed, it becomes more difficult for the resulting interior spatial structure and layout to be reconfigured in different ways to meet possible needs in the future (Tu, 2000).
3. Difficult to repair or replace pipe work: Since the plumbing pipes are typically laid within walls or slabs, it becomes difficult or sometimes impossible to detect, repair, or replace faulty pipes, which often occur when buildings get older (Cheng, 2001).

The full scale double deck (or raised floor) construction, often seen in European or Japanese residential buildings (Kendall and Teicher, 2000), represents a possible solution to these post-occupancy problems. However, its higher cost and poorer acoustic performance have resulted in limited acceptance in apartment buildings in Taiwan. Knowing these critical issues, the author revised the 'full scale' double deck method and developed a new pipe distribution method - the 'restricted' double deck method (RDD), a sustainable method aiming to increase spatial flexibility and facilitate pipe repair work in apartment buildings in Taiwan.

1.3 Objectives

The objectives of this paper are:

1. To present the concept of the restricted double deck method;
2. To estimate the first cost of a typical bathroom construction employing the RDD method and compare it with that employing the conventional in-wall pipe distribution method;
3. To demonstrate the benefits of restricted double deck method.

2. THE RESTRICTED DOUBLE DECK (RDD) METHOD

The RDD method proposes that a horizontal pipe-distribution cavity space is created to accommodate pipes connecting the wet spaces and the vertical shaft in apartment buildings. The RDD method consists of two major construction parts to be explained as followed.

2.1 Double Deck Construction in Corridor Area as the Horizontal Shaft

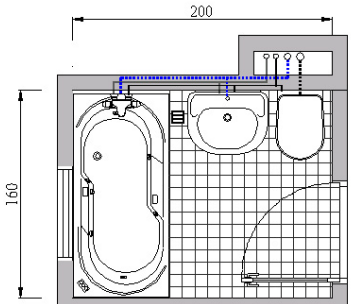
The RDD method proposes that the double deck construction be applied to a limited area in apartment units, usually along the major corridor or circulation area (Figure 2, shaded area in Figure 3-a), to form a horizontal shaft space, within which sloped water supply and wastewater pipes are distributed between the vertical shaft and the wet spaces (kitchen or bathrooms). The double deck construction includes a dropped slab, two beams, two horizontal 'lips' - short slabs extruding 45cm from the beams to allow the pipes from the wet spaces to enter the distribution space (point A in Figure 3), and 90cm wide floor plates (60cm in length) that are removable for accessing plumbing pipes (Figure 3-b). The depth of the double deck depends on the vertical depth required to run sloped pipes from the wet spaces to the vertical shaft. The vertical shaft should be located near places, such as balcony, to allow easy access.

2.2 Pre-wall Installation as Horizontal Pipe Distribution within the Wet Spaces

In the RDD method, it is suggested that the pre-wall installation concept, instead of the conventional in-wall method, be applied to create a cavity space for horizontal pipe distribution 'within' the wet spaces (bathroom or kitechen). The cavity space (approximately 20 cm deep and 100~120 cm high), built of metal frame and gypsum board, is created in front of and along the wall. The waste from various equipment is discharged into the pipes that run through the cavity space, penetrate the slab (the 'lips') along the double deck area (point A in Figure 3), and enter the horizontal shaft space below. The pre-wall installation method requires certain special bathroom equipment, such as water tank embedded in the cavity space, wall-hung toilet or toilet with lateral discharge, and in-slab floor drain.

3. THE FIRST COST

To understand the cost implication of the RDD method, this research estimated and compared the first costs of a typical bathroom design and construction, with the net dimension of 160cm*200cm, that employs both the RDD method and the conventional in-wall method. Given the same wall-to-wall dimension and equipment layout, the costs of floor, ceiling, and wall construction, major equipment, and other accessories within the bathrooms are calculated. The bathroom applying the in-wall distribution method is used as a base case with which the construction and equipment cost of the RDD method is compared. Table 1 shows the cost estimation results of both pipe distribution methods. The particular construction and equipment required by the RDD method which result in different costs from the conventional in-wall method are highlighted by bold characters in the table.



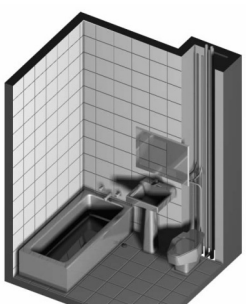


Figure 1. Conventional in-wall distribution method: the floor plan and the perspective.

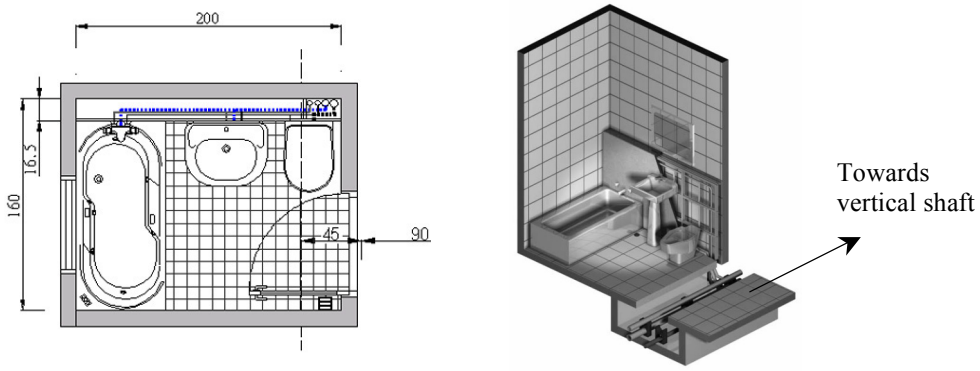
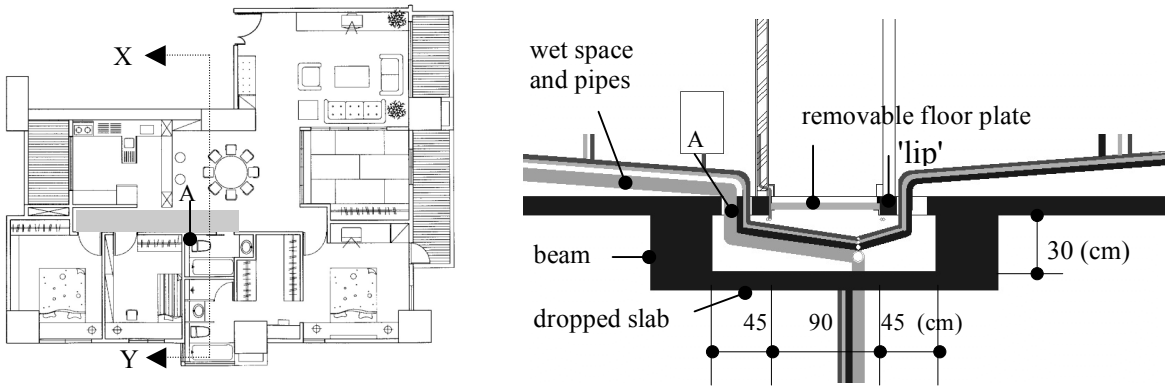


Figure 2. Restricted double deck distribution method: the floor plan and the perspective.



a. Floor plan b. Cross section (X-Y) of the corridodr area

Figure 3. The plan view (shaded area) and cross section of the area employing RDD.

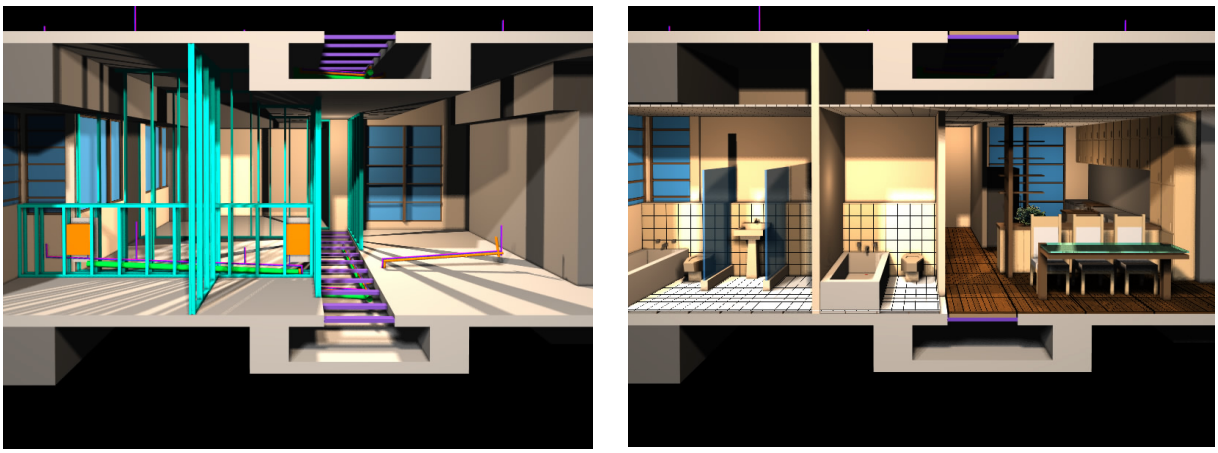


Figure 4. Interior perspective views simulating the construction process of an apartment unit applying the RDD method.

Table 1. The first costs of a typical bathroom applying two pipe distribution methods.

Cost[1, 2]	**Conventional In-wall Method**	**Restricted Double Deck**
Major Construction		
Floor	3,500 (floor tile)	3,500 (floor tile) **25,000 (double deck**[3]**)**
Ceiling	3,000 (hung ceiling)	3,000 (hung ceiling)
Wall	19,500 (tile)	**23,500** (**metal frame+board**+tile)
Major Equipment		

	Sink + faucet	6,500		6,500	
	Bathtub + faucet	11,500		11,500	
	Toilet	21,000	(one piece flush tank)	21,000	(one piece flush tank)
	Floor drain	2,000	(penetrate slab)	2,000	(penetrate slab)
Other Accessories					
	Mirror	3,800		3,800	
	Fan	2,000		2,000	
	Racks	2,200		2,200	
Total cost - one bathroom (Cost in excess of in-wall)		**75,000**		**104,000**	(**+29,000**, 40%)
Total cost - two bathrooms (Cost in excess of in-wall)		**150,000**		**183,000**[4]	(**+33,000**, 22%)

Notes 1. All cost numbers are list prices in New Taiwan Dollar.
2. Cost estimations were obtained from sales representatives of related products.
3. Includes construction costs of 1.8m*9m RC (beam + slab) & 0.9m*7.2m raised floor plates and frames.
4. The same double deck construction can be used by both bathrooms, and therefore its cost is counted once only.

Table 1 shows that it costs NT$ 75,000 to construct a typical bathroom employing the conventional in-wall pipe distribution method. In contrast, it costs NT$ 104,000 to construct a typical bathroom emplying the RDD method, which is NT$29,000, 40% more than that of the conventional in-wall method. The additional cost of the RDD method results from two required constructions: (1) the double deck construction in the corridor area in the apartment unit to distribute horizontal pipes, and (2) the pre-wall installation (metal frames and boards) within the bathroom to house horizontal pipes.

With 40% more cost, it may seem that the RDD method is not a viable for apartments with one bathroom, as compared to the conventional in-wall method. However, it becomes a more competitive solution to construct two bathrooms, which costs only NT$33,000, 22%, more than the conventional in-wall method. In other words, the RDD method would be a feasible method if it can provide occupants with additional benefits that's worth NT$33,000 or more.

4. THE BENEFITS

Compared to the conventional in-wall pipe distribution method, the RDD method retains the same level of building performance, whereas represents a more sustainable method that increases spatial flexibility and allows easy renovation and maintenance (Table 2).

4.1 Sustainability

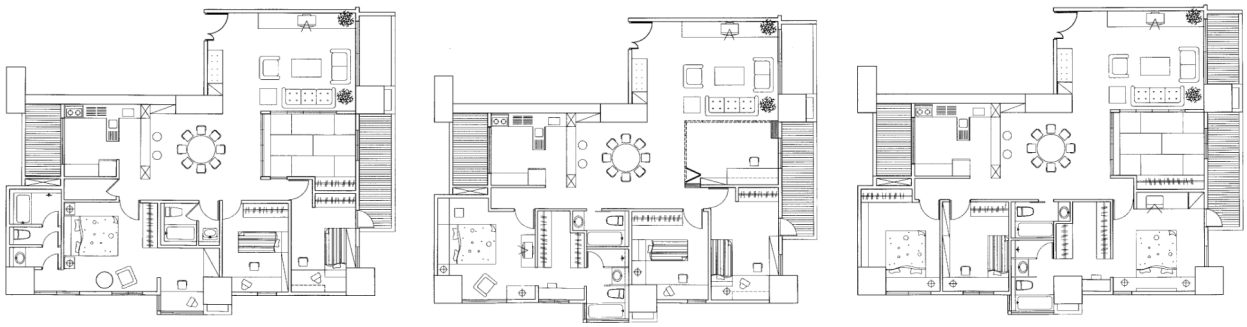
Since the RDD method is able to make inteior space adaptable to a variety of interior layout needs, it is feasible to construct apartment units without partitions in the first place. The construction of interior walls can take place once the occupants move in and the preferrable inteior layouts are decided. As a result, unnecessary demolition of new walls and construction waste can be minimized. In addition, the design of removable and reusable floor plates of the double deck and the metal frame and boards in the wet space areas can also minimize waste production during the process of repairing pipes or renovating the interiors. Therefore, the RDD method is more sustainable than the conventional in-wall method (Table 2).

Table 2. Comparative study on the benefits of two pipe distribution methods.

Comparison of Benefits	Conventional In-wall Method	Restricted Double Deck
Sustainability		
Construction waste	More	Less
Reusability	No	Yes
Spatial flexibility		
Layout change	Difficult	Easy
Pipe repair effectiveness		
Pipe repair or replacement	Difficult	Easy
Pipe penetrating slab	Yes	No
Spatial implications		
Horizontal (m^2)	0	0.33 (10%)
Vertical (cm)	0	60 (double deck)
Building performance		
Acoustic	Good	Good
Texture/solidity	High	High

4.2 Spatial Flexibility

With the conventional in-wall method, bathrooms can only be located around the vertical shafts. Inflexible bathroom location in turn restricts the spatial flexibility of interior space to accommodate various layouts which may occur at different stages of building life. In constrast, employing the RDD method, bathrooms can be located at anyplace along the double deck corridor. Flexible bathroom location reduces the restriction on layout reconfiguration, and thus results in higher spatial flexibility of interior space to be adaptable to various layouts at different stages (Figure 5).



(a) Floor plan - scenario I (b) Floor plan - scenario II (c) Floor plan - scenario III

Figure 5. The RDD method is more adaptable to the interior layout needs at different stages.

4.3 Pipe Repair Effectiveness

With the conventional in-wall method, the pipes are laid within the walls or slabs in bathrooms, and it is therefore difficult or sometimes impossible to identify, repair, or replace faulty pipes. In constrast, employing the RDD method, the pipes are distributed within the double deck in the corridor area and the pre-wall cavity in the bathrooms. The designs of removable floor plates of the double deck and the metal frame and board construction within bathrooms ensure easy access to the pipes, and thus make it more effective and easier to repair or replace faulty pipes (Table 2).

4.4 Others

The major drawback of the RDD method is that it is less spatially effective. As Table 2 shows, the RDD method requires additional 0.33 m^2 floor area for the pre-wall construction within the bathroom to house horizontal pipes, and requires roughly 60cm deep of double

deck space below the corridor area for horizontal pipe distribution. The double deck construction creates an uneven ceiling in the interior within the apartment unit, which may not be acceptable to some occupants.

5. CONCLUSION

In the era of sustainable construction, the conventional in-wall method will no longer be a viable method for pipe distribution in bathrooms in Taiwan. This paper proposes the RDD method as a new approach for pipe distribution, and compares its costs and benefits to the conventional in-wall method. The comparative study shows that, with additional 22% of first cost and the benefits of higher spatial flexibility and pipe repair effectiveness, the RDD method appears to be a viable and sustainable solution for pipe distribution.

The concept of RDD method requires further study and development. It is suggested that, given the current patterns or frequency of interior renovation and pipe repair that occur during the life of residential buildings in Taiwan, the monetary values of its benefits (higher sustainability, spatial flexibility, and pipe repair effectiveness) be quantified and life cycle cost analysis be performed to examine the fiscal feasibility of the RDD method over the whole lifecycle of apartment buildings. Effort should then be directed to the development of related products and details that can make RDD a feasible method and solution for horizontal pipe distribution in residential bathrooms in Taiwan.

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„Building-Passport Schleswig-Holstein“ – Supporting and Labelling Quality and Environmental Awareness in the Building Sector

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INTRODUCTION

The Institute of Ecological and Regional Development (IOER) is a research institute, which is mainly publicly funded[2] and with its Dept. “Housing and Building Ecology” is active in the areas of documentation, evaluation, and communication of environmental properties of buildings. Some of the key terms in this context are ‘Building Passport’ and ‘environmental labelling for buildings’. The term ‘Building Passport’ is currently being used with differing meanings. It can denote a two-paged certificate displaying the most important performance characteristics and technological data of a building - comparable with motor vehicle documents – as well as a comprehensive collection of various building-related documents (plans, calculations, lists and declarations of materials and products used, operating and maintenance guidelines etc.).

In this context, the federal state of Schleswig-Holstein commissioned the IOER to develop the basic structure for a ‘Building Passport’-scheme (Blum et al. 2001). The main target of the project was to outline an instrument which was to render both information on building quality in general as well as open a perspective on environmental characteristics and performance criteria. The instrument is supposed to provide guidance for user groups (architects, planners, clients, owners, tenants, financiers) and thereby support appropriate decision making and at the same time serve as a means for strengthening the competitiveness of extraordinary voluntary environmental performance in building practice.

This paper gives an overall view on the „Building Passport Schleswig-Holstein“, which is here considered as a toolbox rather than a single instrument. The framework and starting points of the development are explained and the core elements of the scheme presented.

FRAMING CONDITIONS AND STARTING POINTS

The development of the “Building Passport Schleswig-Holstein” was carried out in three stages: stock-taking of existing specific conditions and possible ‘anchor-points’, definition of the aims and requirements of the political players and interest groups in the building and construction industry, and finally a draft of the basic concept and development of an implementation scheme.

[2] IOER is jointly funded by the German Federal Ministry of Traffic, Building and Housing (BMVBW) and the Ministry of Science and Arts of the Federal State of Saxony. The project “Building Passport Schleswig-Holstein” was financed by the Ministry of the Interior of the Federal State of Schleswig-Holstein.

Existing tools and 'anchor-points'
The political and economic conditions in Germany, (especially with the recently enacted energy saving ordinance, increasing energy prices and a tendency towards tenant-dominated markets) along with the numerous specific initiatives and programs in ecologically-oriented construction in Schleswig-Holstein, provide a good starting point for the development and implementation of a 'Building Passport'. In particular, a committed *"Low Energy Standard for Buildings"* was included in the public guidelines for subsidised housing development of the federal state long before it became part of the general building legislation. Measures in the *"Initiative Program for Thermal Refurbishment"* attempt at supplying information as a basis for environmentally responsible action.

The *"Criteria for ecological planning and building"* published by the Ministry for Nature and the Environment of the federal state of Schleswig-Holstein as far back as 1993 are also particularly noteworthy. Irrespective of the degree to which some of the criteria today had to be revised (energetic requirements, for instance), the content of the brochure may, on the whole, be seen as a public consensus and thus provides an excellent starting point for the conception of an updated 'Building Passport'.

Expectations, reservations and requirements expressed by the interest groups
In order to achieve a high level of acceptability communication with the interest groups made up a large part of the project work. Representatives of the major institutions concerned in Schleswig-Holstein were interviewed by telephone and questioned on their opinion on issues of a 'Building Passport'. Additional information came from an earlier nationwide study (Blum et al., 1999). The results of the survey were presented as a feedback to the participants at a workshop with the aim of focussing major topics. The following essential issues were recorded for the conception of a 'Building Passport':

- the basic problem of *formulating clear goals* and the identification of target groups,
- the main focus of *quality assurance* (with integration of ecological goals and in particular goals related to health issues),
- the *simplicity* of the tool with regard to *readability/comprehensibility* as well as
- orientation on *information for the end user*.
- Regarding the issues to be included, the topics of building materials choice (ecological aspects and health issues) and energy were stressed as being most important.

Political targets
With the aim of defining the central objectives of the political players involved four typical scenarios were outlined for appropriate 'Building Passport' concepts and were presented for discussion with the advisory board of experts. The four scenarios were labelled *"Good construction Practice / Assurance of Quality"* (main focus: traditional/classic qualities in building and construction as the basis for ecological orientation), *"Ecological performance through competition"* (main focus widespread implementation and transparency), *"Ecological excellence "* (main focus in environmental policy: promoting innovation) and *"Foot in the Door"* (a combination of (low level) tools and long-term implementation).

The discussions resulted in the decision to use a combination of scenarios one and two as the primary orientation with the main target being assurance of quality. Ecological aspects were regarded as an important component of general quality in building. The implementation was to be achievable essentially through the market. Nevertheless during the discussions with the advisory board it was suggested that the "protected sphere" of the semi-public intermediary organisations be used. This suggestion referred in particular to the "Working Group of

Contemporary Construction“ in Schleswig-Holstein. Almost all important local institutions of the building and construction industry and housing development are represented in this association. It belongs to its core tasks to give technical consultancy for subsidised housing projects with more than seven dwellings and check for superior quality. This situation predestines this association as a link between private economy and public players in the further development and implementation of a ‘Building Passport’ for Schleswig-Holstein.

Basic models
As a starting point for the design of the “Building Passport Schleswig Holstein” *three typical separate models* were drafted. These models represent the three basic components of a comprehensive approach – documentation, evaluation, awarding/communication:

Model ‘Building Logbook’. Especially in the case of owners of buildings and tenants, there is a need to introduce a tool that besides presenting data on the properties of the building and archiving relevant documents also provides guidelines for operation and maintenance. As a “building logbook“ it should be kept up-to-date by the user or owner, for instance with regard to ressource consumption (water, energy etc.), maintenance, and structural changes. The “building logbook“ itself does not include any assessment but is the basis for further modules that can be added.

Model ‘Building Passport’. As inspection regulations under public law are being increasingly reduced there is a shortage in monitoring the technological properties of buildings. At the same time requirements on planning and good building practice grow steadily and the need for new forms of quality assurance achieved by means of free market tools increases. The concept of a building passport as an independent tool therefore is a good starting-point. Although buildings are not explicitly assessed, a widespread use of descriptive ‘Building Passports’ can lead to better market transparency by means of gradually developing a certified reference system.

Model ‘Quality label’. A quality label for buildings as an element of an ambitious building and environmental policy formally puts into operation the main goals of the issuing institution – in this case the federal state of Schleswig-Holstein – with regard to a sustainable development in the building and construction industry. The quality label honours outstanding voluntary and innovative achievements concerning environmental and health aspects in building projects. As well as being effective in marketing, a label, which is awarded as publicly as possible, should also communicate best practice.

BASIC CONCEPTION OF THE “BUILDING PASSPORT SCHLESWIG-HOLSTEIN”

Integrated definition of quality
Whilst working on the project, different primary aims and requirements of the “Building Passport Schleswig-Holstein” became clear. The following aims in particular should be mentioned: achievement of widest possible utilisation (to make the application of the tool affordable!), creation of a (pragmatic) tool that is marketable (‘Building Passport’ as a service), achievement of quality assurance and promotion of environmentally oriented construction that also takes health issues into account. To comply with this requirements an integrated definition of quality is necessary. In detail this definition of quality in the basic concept of the “Building Passport Schleswig-Holstein” compiles the following core elements:

Quality of Building / Quality of construction and planning. The necessity for all parties involved in construction to develop an awareness of quality and sensitivity to typical weak points, especially with regard to buildings that have requirements for low energy consumption stands in the foreground. Quality in this sense denotes a reduction in the risk of shortcomings in technical quality and cases of damages in buildings. Consultancy during the planning stage, monitoring throughout the construction process and final inspection of the building (cf. below) are central to an appropriate process.

Environmental Quality. Unlike problems of (technical) building quality, which at least can generally be dealt with objectively by means of technology and legal requirements, the definition of the environmental quality of a building heavily depends on a political (or more general: social) consensus regarding environmental aims and criteria. For this reason, the 'Criteria for Ecological Planning and Building' mentioned above were referred to in this project. Particularly regarding a widespread implementation, the 'minimum standards' laid down in this manual provide a very good starting position for development of a basic conception for the 'Building Passport'. By listing 'further measures' the criteria are made dynamic: The guidelines presented are more than just the political consensus of the moment (at the time of publication, 1993) but rather include further reaching recommendations that opt as the basis for future development.

Health Aware Construction: The assessment of the degree to which a building considers health issues in a 'Building Passport' is methodically difficult due to various reasons. This applies both to the methodology of actual measurements and the standards used in evaluation along with the fact that well-being and health cannot be separated from individual user-specific requirements and sensitivities. Therefore, the examination of the finished building with regard to health-related issues by means of comprehensive monitoring of chemically, biologically and physically harmful substances in the 'Building Passport' does not appear appropriate. It would also not comply to the aim of keeping costs low. Estimation of health risks and their reduction to a minimum should be handled beforehand by measures such as choice of location, careful planning, well-targeted choice of building materials, documentation and declaration (!) (e.g. through product and material lists). Monitoring for harmful substances should only be restricted to cases of actual doubts and then be selective and well targeted.

Components of the basic conception of the 'Building Passport'

Based on the integrated definition of quality laid down above a concept for the tool was suggested that combines 'soft' pragmatic elements (checklists, consultancy) with actual requirements regarding priority target areas (air tightness, energy consumption, building materials etc.). In accordance with the general aim of supporting high quality construction, this approach cannot be limited purely to documentation of the (eventually inadequate) status quo. Therefore the range of tools covers *consultancy* during the planning and *monitoring* during the construction process before entering the phases of *documentation, certification* and *up-dating*. It is important that the tool is not centred around control and the imposition of 'correct' solutions but rather around cooperation according to the principle that "two heads are better than one". The basis for this cooperation is the approach already described, i.e. promotion of high quality construction not by means of stipulating desired characteristics of a building but rather by creating a general awareness of quality issues and especially the risks of quality failure. Experience of external consultancy in the area of subsidised building in Schleswig-Holstein shows that it is possible not only to qualify a project but also as a general rule to save costs in this process. The basic concept for the "Building Passport Schleswig-

Holstein" developed as a basis for further discussion and development contains five main components (Figure 1):

1. Consultancy. The consultancy component includes an initial review, which is free of charge (clarification and discussion of project aims) and a more detailed consultancy as a basis for planning. In order to prepare detailed consultation the parties interested are handed out a "Planning Checklist". The specification of monitoring focuses during the construction process is also discussed during the second consultation stage. The consultancy is primarily aimed at the building contractors' architects or project managers. The participation of the client is desirable (team orientation, 'awareness of quality').

2. Guidance / Monitoring / Final inspection: Guidance includes one or several intensive on-site inspections during which sensitive/problematic points or building phases identified in the consultation are monitored, as well as random checks as need arises. The final inspection consists of a review of the completed building and in particular includes a test for airtightness ("blower door"-measurement).

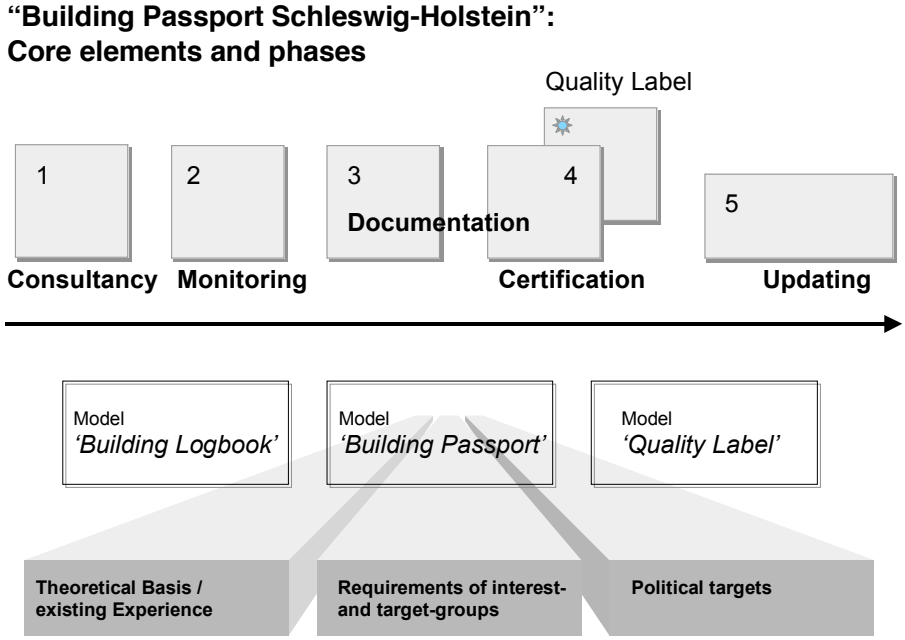

Figure 1: Basis, starting points and core-elements of the basic conception for the "Building Passport Schleswig Holstein" (Blum et al, 2002)

3. Documentation / 'Building Logbook'. The documentation corresponds in principle to the building documentation described as last planning stage in the German federal regulations on remuneration of architects and engineers. Nevertheless it is supplemented by documents specific to the 'Building Passport' such as the planning checklist, records of the inspections or the list of materials used. A pre-prepared index is provided as a formal basis ('Building Logbook'). The 'Building Logbook' is a supplement to the actual 'Building Passport' (cf. certification).

4. Certification / 'Building Passport'; extension to a 'Quality label'. The certification process leads to the actual issuing of the 'Building Passport'. Certification primarily refers to

the formal requirements of the 'Building Passport' procedure. Regarding the content compliance with the ordinance on energy saving in buildings mentioned above is a central point. In addition, fulfilment of certain criteria in the planning checklist will be checked including the degree to which the material recommendations have been adopted. An extension of the 'Building Passport' into a graded quality label by coupling it with minimum standards regarding procedures or content is possible. The 'Building Passport' is valid for a period of four years at first.

5. Continuous Use / Updating. Structured updating and archiving of important documents and information on a building over the whole lifetime is a significant element of the "Building Passport Schleswig-Holstein". A logbook that has been kept up-to-date provides important basic information both in the case of letting or selling of the building, and in building operation in general from everyday use to modification or maintenance and renovation. Maintenance of the building logbook and updating of the 'Building Passport' is supposed to take place during and after the four years' validity and is required when applying for an extension of the passport.

CONCLUSION: SETTING A GOOD EXAMPLE

Within the basic framework for the "Building Passport Schleswig-Holstein" also suggestions for an implementation strategy were made. Beside questions like organizational structure, financing, review-process etc. as a concluding result it was also recommended to start with the implementation of the "Guideline of Sustainable Building" which was published at the beginning of 2001 by the German Ministry of Transport, Building and Housing for federal buildings (BMVBW 2001). It was suggested that – accompanying the general 'Building Passport' process – a system of environmental and quality management including a 'Building Passport' be set up for buildings in possession of the federal state of Schleswig-Holstein. This would not only incur positive environmental (and economic as the federal guideline shows!) effects but also state a good public example as a crucial signal in order to support the implementation of the general tool "Building Passport Schleswig-Holstein".

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Remediation for housing and recreational areas at the former Norwegian main airport at Fornebu

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INTRODUCTION

The former Norwegian main airport (at Fornebu) will become a residential and commercial area with large green areas and nature reserves. The fact that many people will be living and/or working in these area means that strict requirements are set for cleaning up all the ground contamination. Statsbygg is responsible for remedial measures that are needed at each location. As a basis for the assessment of remedial measures, 5 environmental targets for reuse have been drawn up.

1. There must be no ground contamination capable of harming human health.
2. There must be no danger of dispersion of environmentally harmful substances.
3. There must be no leaching of environmentally harmful substances to the fjords.
4. Any substances that may be converted into hazardous substances must be pinpointed.
5. There must be no volatile substances that produce unpleasant odours or detrimental effects on the quality of life.

A site-specific risk assessment will clarify the need for action at each site. Remedial measures will be carried out before the development of the site can begin.

The main clean up started last year and will be carried out during a 4-year period, to 2003. After treatment, the former contaminated soil will be used for landscaping in accordance with the overall plan for soil management. Reuse of treated soil (together with asphalt and concrete) is one of the main environmental targets for the development of the Fornebu area.

IMPLEMENTATION OF CLEAN-UP

Clean-up targets and requirements

The overall target for the clean up at Fornebu is to remove sources of contamination that represent an environmental threat or conflict with the future use of the area. This will require fulfilment of the five specific environmental targets that form the basis for planning and implementation of measures.

Risk assessment

Remedial action will be carried out at all sites in which one or more environmental targets have not been satisfied. The environmental targets for clean-up of the contaminated sites at Fornebu are primarily connected with human use of the former airport area. If the land use for an area is changed, the environmental targets will change too. The following land use categories emerge for the establishment of action standards at Fornebu:

1. Residential areas. This includes housing, housing/offices and nursery schools/playgrounds located in the residential areas:
   1a) Residential < 1 m depth
   1b) Residential > 1 m depth

2. Commercial areas. This includes business, business/industry and roads.
   2a) Commercial areas, impervious surfaces incl. buildings
   2b) Commercial areas, all open outdoor areas

3. Recreation. This includes sports and park facilities, outdoor recreation areas and cemeteries (excl. buildings)

4. Other public areas. This includes official/public, community centres, sports facilities/schools and nursery schools outside the residential areas.

5. Buffer zones towards nature reserves.

Conservation under the Nature Conservation Act includes protected areas that require special treatment. Water is assessed with reference to the dispersion action standard. The dispersion action standards will ensure that there is no danger of dispersion of contamination. The following factors are to be investigated:

- Whether contamination may be spread by pore-water to plant life in unacceptable concentrations (uppermost metre of soil).
- Whether contamination may be spread to adjacent uncontaminated soil in concentrations that cause conflicts in terms of land use.
- Whether contamination may be spread to the fjords in critical concentrations for marine organisms. Critical concentrations for aquatic organisms or existing environmental quality classifications for the sea are compared in the risk model for Fornebu.
- Whether volatile substances from pollutants may be spread in unacceptable concentrations. Odour thresholds for substances for which data are available are compared in the risk model for Fornebu.

DOCUMENTATION AND CONTROL

Great importance is attached to checking and documenting the fact that all contaminated soil is properly dealt with, and that no dispersion of contamination occurs during excavation, sorting or treatment.

- For this purpose, directions have been drawn up for the excavation and monitoring of contamination at each site.
- In addition, a contingency plan has been prepared for unforeseen and acute contamination situations during the course of development.

Pollution requirements for intermediate storage and final disposal of pollutants are laid down in the State Pollution Controls Authority's general clean-up permit and are based on the above environmental targets. In accordance with these targets, soil that has been treated may be used for landscaping in commercial and recreational areas, or deposited in areas where this does not conflict with land use or recipient. Intermediate storage of contaminated soils will require impervious covering and confinement of seepage water to prevent dispersion of contamination.

The landowners have also drawn up a soil management plan, to estimate the effects for the landscape of excavation, removal and depositing. This soil management plan is including

strategies for the reuse of different types of soils at Fornebu, including soil that has been cleaned by the treatment plant.

CHOICE OF MEASURES

Possible measures for meeting the targets are as follows:

- Soils to be excavated and treated at a suitable local treatment plant area at Fornebu
- Soils to be excavated and sent to an approved treatment plant or disposal site outside Fornebu
- Contaminated soils to be sealed off and covered in situ (not an option for some types of contamination, e.g. glycol)
- Remedial measures to be undertaken in situ, without prior excavation. (For example, such measures might involve the addition of water, air or nutrients, or changing the ground temperature in order to stimulate a more rapid breakdown of organic pollutants such as oil and glycol.)

The kind of procedure chosen is primarily dependent on the nature of the pollution, future land use in the area and the speed at which the clean-up must be completed.

Oil contaminated soil

Oil contaminated soil is treated in by composting. This is a cheap method, requiring modest investment in comparison to alternative types of process. The soils are laid out in windrows and aerated. For the next season some nutrients probably will be added. However, windrow composting is space consuming, and a minimum of one year's treatment time must be allowed before the soil is clean enough to be used in commercial or recreational areas.

PAH-contaminated soil

PAHs are organic compounds, which can also be broken down by composting, but the breakdown time depends on the compounds that are present (the size of the PAH molecules and their persistence). Generally speaking, PAH-contaminated soil will require a longer treatment time than oil-contaminated soil.

Persistent PAH compounds (four rings or more) are slowly degradable and are not very mobile in the ground. If it can be shown that the contamination have little mobility and therefore do not represent any hazard to health, it may - in places - prove possible to leave it untouched or to deposit the contaminated soil under areas to be covered by asphalt or clean soil.

Soil contaminated by de-icing chemicals

The de-icing of aircrafts at Fornebu has caused glycol contamination in ground and groundwater. Glycol is an organic, easily degradable contaminant. Of particular importance will be the oxygen supply, to prevent the occurrence of anaerobic biological processes that cause an offensive onion odour. This will be carried out by pumping up contaminated groundwater and during aeration degrade the glykol and odour compounds. Alternatively, degradation of glycol can be promoted directly in the ground, without prior excavation.

However, some additives used in the de-icing fluids may inhibit treatment. The possibility of success for this kind of treatment is investigated.

Soil contaminated by heavy metals

The greater quantity will consist of mildly contaminated soils from older waste disposal sites, where the values probably will not exceed the SFT's requirements for soil quality in

commercial or recreational areas. Because these landfills are relatively old (from 1937-1947), studies have shown that the residual metals have little mobility. The soils excavated will be used as filling-in materials in commercial and recreational areas as studies have proved that this will have no negative environmental effects.

The degree to which there will be a need to excavate the older landfill sites will largely depend on the future landscape configuration at Fornebu, including the layout of infrastructure, surface water treatment, and the level of the central pond.

ESTABLISHMENT OF TEMPORARY TREATMENT PLANT

On the basis of available studies and experience from similar clean-up operations, a provisional estimate has been produced of the volume of contaminated soils at Fornebu, cf. Table 1.

TABLE 1. Sorting of contaminated materials into different categories.

CATEGORY	**QUANTITY (m^3)**	**HANDLING**
Topsoil to be excavated	100-300,000 Clean soils→ Mildly contaminated soils→	Unrestricted disposal Reuse in line with environmental targets
Contaminated soil	35,000	Local outdoor treatment
Severely contaminated soil	5,000	Local indoor treatment
PAH-contaminated foundation materials	15,000 → 5,000 →	Can be sorted, treated and reused at Fornebu To external plant
Hazardous waste and soil that cannot be treated at Fornebu.	5,000	To external plant
TOTAL **Excavated materials**	**165,000-365,000**	Rough sorting on site, detailed sorting at treatment plant

At the sites that will be excavated, the materials will be sorted on the spot, with the aid of chemical analysis field equipment. Clean soils, metal residues, coarse waste and hazardous waste will largely be sorted out during the excavation. Such on-site sorting will substantially reduce the quantity to be passed on to the treatment plant. The net quantity of soils to be treated at the plant is estimated to 55,000m^3, cf. Table 1.

An important environmental target for the development at Fornebu is to deal with most of the excavated materials locally, in order to restrict transportation. This applies to contaminated soils also. Once treatment has been completed, as much as possible of these soils is to be returned to the development areas. In order to achieve this, a local treatment plant at Fornebu has been established.

Location and design of plant

Two sheds are established on the runway at Storøya, making it possible to deal with the most severely contaminated soils indoors. Biological treatment is carried out on the 20.000 m2 outdoor area. Run off water is collected in 2 basins and handled according to an emission permit for seepage water issued by SFT.

APPROVAL OF MEASURES, CONTROL AND REPORTING

The SFT's requirements for the treatment of contaminated soils at Fornebu are laid down in the form of a general permit for the landowners to implement measures.

For its part, Bærum Municipality has approved the construction plans for the plant and soil management involved in the clean up. They have granted a general permit for the works under the Planning and Building Act, together with the necessary start-up permits.

Based on the general terms granted by the SFT and Bærum Municipality, an action plan will be drawn up for each individual site, including specific statements of the measures to be implemented and how the excavated soils are to be sorted, monitored and treated. As a foundation for selection of measures a site-specific risk assessment will be carried out, based on the planned land use of each site.

Both SFT and Bærum Municipality will process the action plan, before remedial works are initiated at a site. After remedial measures have been carried out, there will be a final check to ensure that the measures have had the intended effect. A final report will be drawn up for each site and all documentation is collected in a geographical information system (GIS).

Decision Support System for the Design of Office Buildings in Senegal

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1. INTRODUCTION

Decisions concerning the use of energy efficiency measures taken at the early design stage are crucial to reduce the environmental impact of the energy used in buildings. Energy efficiency measures should reduce i) the operating energy and energy embodied in building components, ii) the related environmental impacts and iii) the life-cycle cost of buildings. The possibilities of optimising the design of buildings on the basis of these criteria are numerous. Clearly, architects are in need of a tool to help them at the design stage to easily and quickly (this is essential) evaluate the performance of the various design alternatives they may consider. This paper reports on such a tool, packaged in the form of a computerised decision support system (DSS), which was developed for architects of Senegal.

The DSS is based on a four-part procedure: (1) definition of a generic reference building, (2) selection of design alternatives, (3) determination of the embodied and operating energy, the carbon dioxide emissions and the life-cycle cost associated with these alternatives, and (4) selection of the most appropriate measures using a multicriteria evaluation technique.

2. REFERENCE BUILDING

The reference eight-floor office building is situated in Dakar, the capital of Senegal. The building has a rectangular footprint, with a total floor area of about 1700 m^2. The ceiling height is 2.7 m. Walls are composed of 15 to 22 cm thick block walls, with clear glass windows. Dark-coloured drapes are used to protect the interior spaces from solar radiation. The window-to-wall ratio is 0.9. Floor slabs are made of 37 cm thick reinforced concrete.

In Dakar, monthly mean temperatures range from 20 to 28 °C, and monthly mean relative humidity, from 47 to 89 %. Internal conditions for cooling, 25 °C and 50 % RH, are maintained in the building through the use of window-type air-conditioning units. There is no heating system.

Fluorescent lamps, installed in suspended luminaires, are used whenever dayligthing is insufficient. The installed electric lighting load is 6 W/m^2. The interaction between artificial lighting and daylighting is manually managed.

3. DESIGN ALTERNATIVES

Several design alternatives are selected, with a particular focus on the building envelope. Seven parameters are considered : wall type (concrete panels or blocks), thickness of thermal insulation of the roof (0, 20, 40 mm), thickness of thermal insulation of the walls (0, 20, 40 mm), overhangs width (0, 60, 80, 100, 120 cm), windows-to-wall ratio (0.9, 0.8, 0.7, 0.6, 0.5), glazing type (clear, tinted, reflecting, double clear, double selective), and drapes colour (dark, light). The translation of these seven parameters into design alternatives leads to 4,500 combinations.

The reference building can be oriented along the four main orientations (east, north, west, south), and can be exposed to three different neighbourhood conditions, leading to twelve reference configurations. Hence, the total number of design alternatives reaches 54,000.

4. EVALUATION CRITERIA

The criteria for the evaluation of different design alternatives are energy consumption, carbon dioxide (CO_2) released, and costs, all being calculated on a life cycle basis. For each design alternative, the index of performance is calculated as the difference from the reference building, and reported for 1 m^2 of floor area. For example, the index of embodied energy is the embodied energy associated with a given design alternative minus the embodied energy of the reference building.

A process analysis was used to determine the energy contents and the CO_2 released in association with the production of the concerned materials, using data collected in Senegal (Ndiaye, 2001).

The energy consumption, CO_2 emissions and costs associated with the maintenance/renovation and demolition/recycling/disposal phases are not considered since these factors are assumed to be negligible in the case when the design alternatives concern only the building envelope.

The annual operating energy consumption and cost associated with each design alternative are determined by computer simulations using DOE-2 (Acrosoft, 1994). Since electricity is the only energy source used in office buildings in Senegal, the CO_2 emissions are calculated using the CO_2-emission factor of electricity produced in Senegal (1.10 kg CO_2/kWh). The indices of performance estimated for each design alternative are integrated into a database composed of 54,000 design alternatives.

5. MULTICRITERIA EVALUATION

Design alternatives are compared using three criteria: energy, CO_2 emissions, and cost. The indices to be considered for each of these criteria may take on one of the five following forms:

- the embodied factor (energy, CO_2, or cost) alone (ΔE_0);
- the operating factor alone, at the end of first year of operation (ΔO_1);
- the operating factor alone and cumulative (during the life-cycle) (ΔO_L);
- the total factor (embodied + operating), at the end of first year of operation (ΔT_1);
- the cumulative total factor (during the life-cycle) (ΔT_L).

As an example, Table 1 shows how five design alternatives are compared in terms of CO_2 emissions using the five forms of the three criteria mentioned above.

Table 1 Example of evaluating design alternatives with CO_2 emissions as criterion.

	ΔE_0 (kg CO_2/m^2)	ΔO_1 (kg CO_2/m^2)	ΔO_L (kg CO_2/m^2)	ΔT_1 (kg CO_2/m^2)	ΔT_L (kg CO_2/m^2)
Alternative 1	0.0	13.0	390.0	13.0	390.0
Alternative 2	0.0	13.1	393.0	13.1	393.0
Alternative 3	-5.3	10.6	318.0	5.3	312.7
Alternative 4	-5.3	15.4	462.0	10.1	456.7
Alternative 5	-0.2	4.5	135.0	4.3	134.8

For the criterion "cost", the cumulative total factor is the life cycle cost. In this study, the present value of the energy cost savings over the life-cycle, denoted by PC_d, is given by (BEE-QC, 1984):

$$PC_d = PC_1 \times \left[\frac{1-(1+t)^{-d}}{t} \right] \tag{1}$$

where:

- PC_1 : savings at the end of the first year of operation
- d : life-cycle (years)
- t : discount rate.

The multicriteria evaluation requires the integration and comparison between indices having different units (e.g., energy cost and CO_2 emissions). The approach used in this study comprises three steps: (1) scoring of each design alternatives for each criterion, (2) weighting each criterion, and (3) calculating the overall or final score of each design alternative in a manner similar to what is done in BEES (Lippiatt, 1998) for instance.

5.1 Individual scoring for each criterion

For each criterion, each design alternative receives a score on a 0 – 100 scale. The design alternative with the highest index (I_{max}) for a given criterion receives a score (called COTE) of 100 with respect to that criterion. A maximum index corresponds to maximum energy or cost savings, or to the maximum reduction of CO_2 emissions. The design alternative with the smallest index (I_{min}) for a given criterion receives a score of 0 with respect to that criterion. All other design alternatives receive scores (I) between 0 and 100, calculated based on the following formula:

$$COTE = \frac{100 \times (I - I_{\min})}{I_{\max} - I_{\min}} \tag{2}$$

5.2 Weighting among criteria

The weighting expresses the preference given by the user to each criteria (energy savings, reduction of CO_2 emissions, and cost savings). A relative weight w_i is given to each criterion i. The sum of the three weights must equal to 1. There are several approaches for assessing the weights (e.g., Kleindorfer et al., 1993). In the present case, characterised by only three

criteria, the method of points allocation is considered to be the most appropriate. In this method, the user is simply asked to distribute 100 points among the criteria. The amount of points obtained by each criterion represents the percentage of its weight in the set.

5.3 Final score

The overall label of performance of each design alternative is assessed by evaluating the final score (COTFIN). Greater is the final score, better is the design alternative. The final score of a design alternative is the weighted sum of its scores for each criterion:

$$COTFIN = (w_E \times COTE_E) + (w_G \times COTE_G) + (w_C \times COTE_C) \quad (3)$$

where:

- w_i : weight of the criterion "i" (E for "energy" / G for "CO_2" / C for "cost")
- $COTE_i$: score of the alternative for the criterion "i".

6. DECISION SUPPORT SYSTEM

The decision support system (DSS) integrates the evaluation method described in the preceding section. The DSS developed using Borland Delphi® is called BURSEN (French acronym for "Office buildings in Senegal") and operates under the Windows® environment. BURSEN is endowed with a user-friendly graphical interface that combines flexibility, ease of use, and explicit handling of errors.

The software operates by project, which corresponds to an office building to design. The user can set the evaluation parameters (the cost of electricity, the economic lifespan, the discount rate for the determination of the life cycle energy cost, and the weights of each criterion) and the embodied factors which will apply to all design alternatives within a project (Figures 1 and 2).

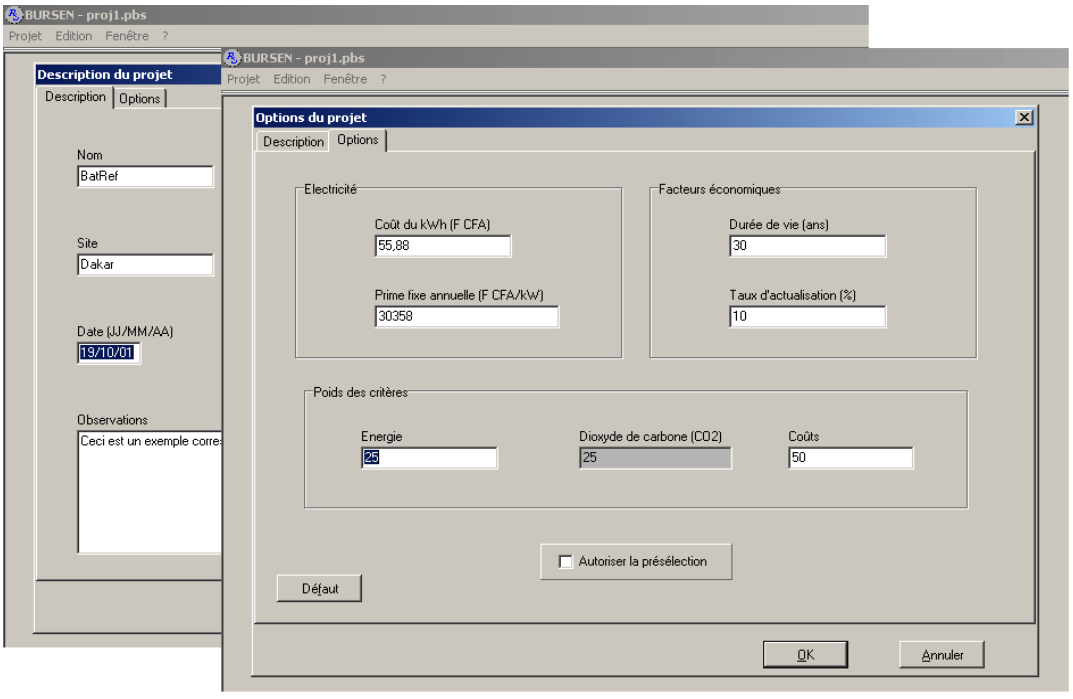

Figure 1 Windows used to set the evaluation parameters.

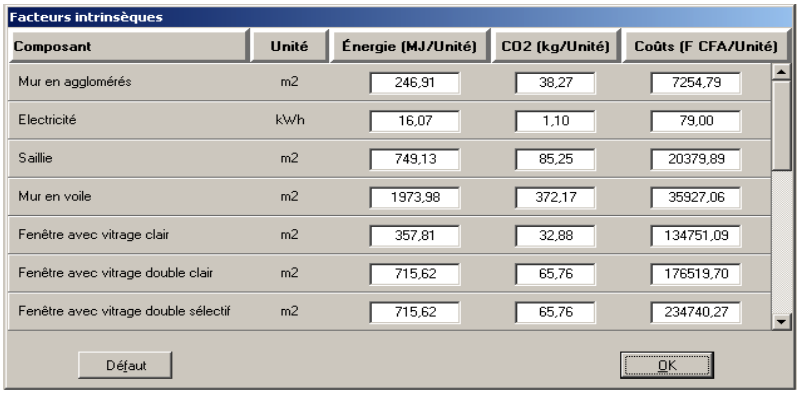

Figure 2 Window used to set the embodied factors.

For each project, the architect defines different design alternatives which are entered using a window such as the one shown in Figure 3. In essence, by using this window, the user selects which alternative, among the 54,000 available in the data base, is considered.

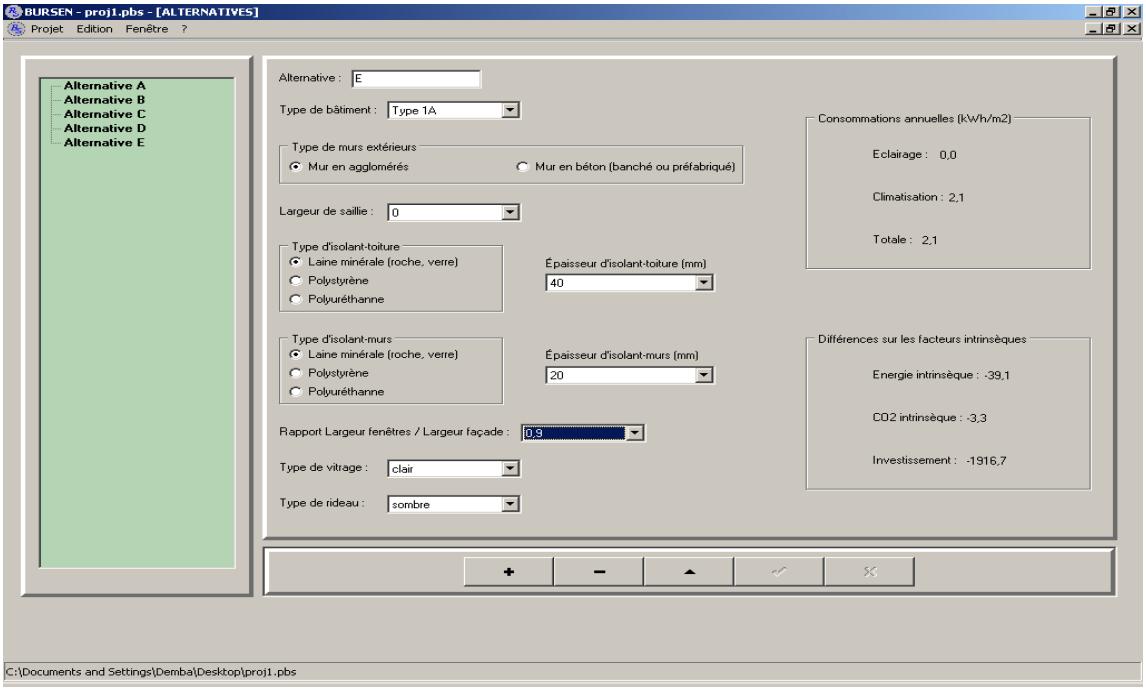

Figure 3 Window to select different design alternatives.

The results of the evaluation are presented under tabular, or graphical forms using charts such as the one shown in Figure 4. The results presented in Figure 4 correspond to the evaluation of a particular selection of five design alternatives (A, B, C, D, E) with $COTE_E$ = 0.25, $COTE_G$ = 0.25, and $COTE_C$ = 0.50 . In this particular case, alternative D has a final score of 100 and represents the best alternative. In fact, it represents the best alternative for each criterion since it has a maximum score (25,25,50) in each category.

7. DISCUSSIONS

Results such as the ones presented in Figure 4 are subject to the selection of the values of $COTE_E$, $COTE_G$, and $COTE_C$. However the DSS is flexible and the user may easily conduct sensitivity analyses to evaluate the impact of several design alternatives.

The database might contain inherited inaccuracies due to: (1) the selection of this particular reference building as a typical office building for Dakar, (2) the estimation of embodied energy in building materials and the corresponding CO_2 emissions, and (3) the simulation of annual energy consumption.

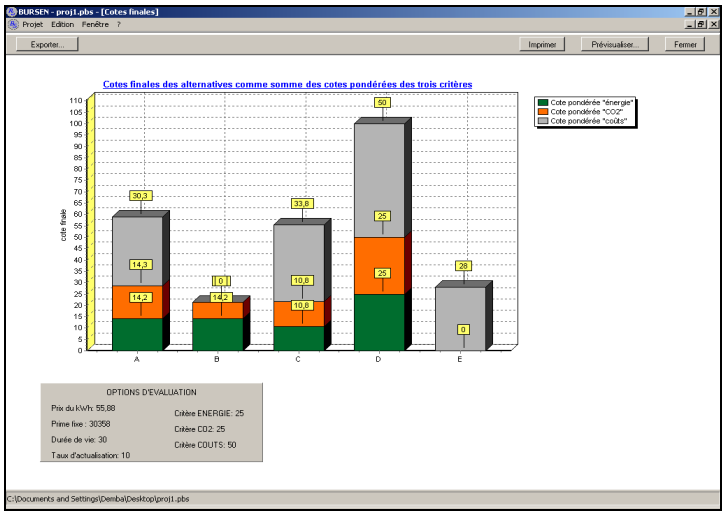

Figure 4 Report presenting the final results under graphical form.

8. CONCLUSION

This paper described the development of a computerised decision support system (DSS) intended to help architects in Senegal optimise the design of office buildings. The evaluation criteria are: the energy savings, the reduction of carbon dioxide emissions and the cost savings, all determined on a life cycle basis. The DSS is called BURSEN and holds a highly user-friendly interface. There are some imprecision sources in the DSS, however they are well counterbalanced by the flexibility of the tool, the possibilities of sensitivity analyses, and finally by the fact that the decisions are taken on a relative basis, and not using the absolute value of each index.

9. ACKNOWLEDGEMENTS

The authors are grateful to Canadian International Development Agency (CIDA) for its support to this research through its PCBF program.

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Proposed Framework for Environmental Assessment of Existing Buildings

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1. BACKGROUND - WHY A FRAMEWORK IS NEEDED

For practical purposes, we regard existing buildings to include any completed building, be it recently-completed, or years or even centuries old. Environmental assessment or rating schemes for existing buildings need to address four main issues, not usually covered by systems intended to predict environmental performance of new building designs.

1. A newly constructed building, as-built, may differ significantly from the design, thus affecting the potential performance.
2. The use, equipment and management of even a new building may differ significantly from that assumed by the designers (and even the client). An as-built operating assessment offers opportunities to review design assumptions, correct deficiencies, and improve performance in operation.
3. In operation, an existing building may be usefully benchmarked against other similar buildings, using an assessment system, in order to improve operations.
4. When addition, renovations or major repairs are undertaken, an assessment system may be used to gauge the potential for improvements.

2. REVIEW OF EXISTING SYSTEMS

A variety of assessment and rating systems for existing buildings are in use around the world. Their origins and intents differ, from tools intended for use at the design stage to post occupancy evaluation tools. Very few systems make a clear distinction between environmental performance based on inherent properties of the building and performance resulting from the operation of the building. The UK's BREEAM for offices does have separate parts for the design and operation, but few links between the two. NABERS, the Australian system now in pilot stage, has different questions for the building and for the user, but does not assign separate ratings for the building and for its operation.

Table 1 Some Existing Systems

Country	System	Summary Comments
United States	LEED	Criteria-based system for existing buildings in pilot stage, language or reference standards modified to reflect operations. USGBC (2001)
United Kingdom	BREEAM	Criteria-based system for office buildings, one third of which is an optional management & operations assessment for occupied buildings.
United Kingdom	PROBE	Research project to improve building performance feedback through post-occupancy evaluations, based on occupant surveys, technical surveys, and a published energy assessment and reporting method.
Germany	EPIQR	Assessment of existing buildings for upgrade or repair purposes. Lützkendorf (2002)
Sweden	Environmental Status of Bldgs.	Criteria-based system modified on members' requirements, no LCA or weighting. Glaumann and von Platen (2002)
Denmark	BEAT	LCA method developed by SBI that treats effects on the environment from use of energy and material. Glaumann and von Platen (2002)
Norway	EcoProfile	*BREEAM*-influenced hierarchic criteria system. Two versions, one for offices and one for residences. Glaumann and von Platen (2002)
Finland	PromisE	Criteria-based system, fixed and operational in four categories; human health, natural resources, ecological consequences and environmental risk management. Aho (2002)
Canada	BREEAM Canada	Adaptations of the UK BREEAM system. Skopek (2002)
Austria	"Comprehensive Renovation"	Criteria-based environmental system for residences to stimulate comprehensive, rather than piece-meal, renovations. Geissler, 2002
Australia	NABERS	Criteria-based system for new & existing buildings, with single rating but different criteria for building and user. Ratings renewed annually. Vale et al (2001)

3. PERFORMANCE REQUIREMENTS FOR THE FRAMEWORK

Existing buildings, by definition, operate within the marketplace, so requirements must address both environmental issues and market characteristics.

General requirements applying to environmental assessment systems:

1. *Methodological transparency.* Allows access and understanding of assumptions, data and other methodological issues influencing the outcome of assessments and consequent ratings. For consumers, this allows conscious choices and meaningful comparisons. For building sector companies it means being able to improve their performance and compete more effectively.
2. *Focus on performance*. Building performance assessment methodologies should be fully performance-based for two reasons. Firstly, assessment on the basis of prescriptive technical features typically prevents buildings without those features from obtaining a good assessment result regardless of actual performance. Secondly, feature-based assessment inevitably encourages "feature-based design and maintenance" of buildings rather than design and maintenance based on performance.

Specific requirements regarding existing buildings:

1. *Life-cycle approach*. Holistic and meaningful results and recommendations require review of life-cycle environmental impacts of the building. The definition of what life-cycle actually means for buildings which might have existed for centuries or decades can be problematic, but various components of a life-cycle approach can provide useful information. These include, starting with the shortest time scale:
   - Utilities requirements to keep the facility operating (energy, transport, water, materials, services, waste).
   - Routine maintenance (painting, cleaning, consumables, routine spare parts).
   - Replacement maintenance due to wear & tear, failure and obsolescence.
   - Alteration, refit and refurbishment.

- Major interventions.

2. *Simplicity and low cost*. Costs of assessing existing buildings are typically met from the annual operation and maintenance expenses budget. This limits the amount of resources available for performance evaluation in comparison to new building (or major refurbishment) projects where the cost of assessment is low in relation to the overall project budget. Costs can be further reduced if the needs of assessment are appreciated at the time of design, refurbishment and alteration, when the design team can provide:
   - Key design information (e.g. building envelope thermal characteristics, design criteria, equipment efficiencies etc.) is recorded in a log book.
   - The results of quality assurance and system commissioning are also recorded
   - Suitable facilities to collect information relevant to ongoing assessment (e.g. utility submetering).
3. *Focus on both potential and actual performance.* Environmental assessment of a new building typically focuses on its predicted potential performance before it is built, relative to some benchmark. Assessment of existing buildings will need to examine both potential and actual performance. Even the potential performance of a newly-completed building is likely to vary from that predicted before it was built, owing to the build quality achieved and the inevitable changes in design, construction, equipment and use that will have occurred. The potential performance is the best performance that can theoretically be obtained from the building with its current levels of occupation and use and in its current condition. The actual performance will generally have more environmental impact than the potential, owing to various forms of waste which is avoidable, at least in principle (occasionally the impact may be less because standards of provision are inadequate!). Actual performance is the real basis of operating costs and resource use, and forms the starting point for analysing the cost effectiveness of the impact of different improvement measures. Figure 1 shows an example of how these might relate to each other.

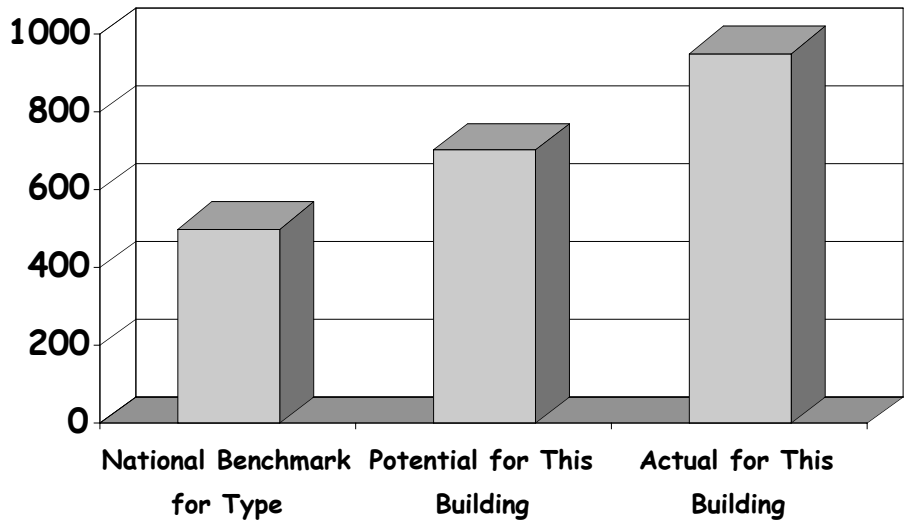

Figure 1 Relationship between benchmark, potential performance and actual

4. *Distinction between building performance and building management.* There are two aspects to the actual performance of a building, as shown in Figure 2. The first aspect is a result of the technical and design characteristics of the building (or asset) and is dependent on, or limited by, the standards to which the building has been built and the efficiency of its fabric and installations). The second is the use of the building and the effectiveness of the management practices deployed in operating and controlling it. In order to be able to

provide meaningful results and appropriate recommendations for action, an environmental assessment system for existing buildings should clearly distinguish between the impact of these two aspects on the final performance of the building.

Since there can be major differences between design predictions and in-use performance,

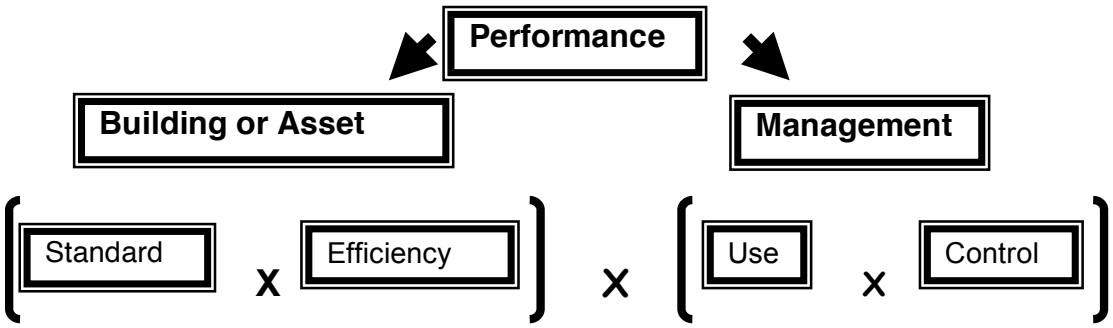

Figure 2 Two basic aspects of actual performance of existing buildings (developed from figure 4 in CIBSE (1999).

the components of performance in figure 2 should also be made explicit at the design stage and linked through to the performance of the building in use. Ideally, the designers would fill in an initial version of the in-use environmental assessment using the design data. This could then be updated with the actual results, both simplifying in-use assessment task and providing a transparent link between anticipated and actual performance. For example, the UK's CIBSE TM22 method (CIBSE, 1999) for building in-use energy assessment (as used in the Probe surveys) is also beginning to be used to record the results of design assumptions and predictions. Similar linkages could be forged between GBT predictions and in-use assessments, at least for some relevant variables.

4. A STRATEGIC APPROACH

A step by step methodology is proposed for capturing the required input information for the assessment, identifying appropriate standards for comparison, understanding the context and making the performance assessment.

1. ***Identify and quantify the inputs and waste streams.***
   Examples include energy consumption by fuel type and use, potable water use, waste water discharge, materials consumed and materials and pollutants discarded to the waste stream. Clear measurement conventions are needed.
2. ***Appreciate the context***.
   This is necessary to facilitate understanding of performance against the benchmarks, so that assessment results can be turned into meaningful recommendations. Context includes imposed variables like climate, weather and location, user factors like occupation, equipment densities and hours of use, conversion factors such as carbon intensity of fuels and other measures of extent such as floor area.
3. ***Quantify functional performance levels***
   These relate to both inputs and outputs. For example:
   - Environmental conditions: what is the illuminance level? is the temperature and humidity closely controlled? and so on.
   - Satisfaction levels: how happy are people with various aspects of the facility?
   - Output levels, e.g. perceived or measured levels of productivity.

4. ***Establish appropriate benchmarks***
   These are necessary to provide representative values, against which the building's actual performance is compared. They can be derived from a number of sources, such as typical practice or good practice levels, client requirements, design expectations, or national or local standards where these are available.
5. ***Calculate environmental performance indices***
   These are derived from the inputs, context information and benchmark categories. An example would be emissions per square metre, per person (or person-year), or per unit of production, all normalised perhaps for climate.
6. ***Compare performance indices and benchmarks to assess performance***
   This may be done with absolute numbers; or scores may be assigned derived from scales dependent on weighted values.
7. ***Come to a judgment of how the performance assessment relates to the context***
   For example water consumption for the assessed building may be good compared to the benchmark, but its components may be assessed very differently, for example:
   - on the "Asset" side of figure 2, the design might be very water-efficient (very good)
   - on the "Management" side, the user requirement for water services might be greater than normal (perhaps owing to shiftwork) - a contextual variable which justifies higher consumption; but at the same time control might be poor owing to poor maintenance and wasteful staff behaviour.

   In this example, in spite of the ostensibly good benchmarked performance, recommendations could still be made for improvements on the management side.

5. WEIGHTING

If overall scores or ratings are used, the issue of weighting needs to be addressed. The weight, or the difference in importance between variables may be explicit or implicit. Current systems use very different methods of weighting, for example:

- BREEAM in the UK uses explicitly derived weightings based on average values held by various segments of British society as determined by survey.
- LEED in the United States has weightings implicit in the distribution of credits awarded for performance in any given area. These weights were arrived at through consensus of the members of the US Green Building Council who developed the system.
- GB Tool, the system used by Green Building Challenge, makes the weights explicit and adjustable by the user in any country, region or context.

If weights are used, they need to be explicit to meet the requirement for transparency.

6. APPROPRIATE VARIABLES FOR ASSESSMENT

Starting from a base of categories in GBTool, the following are potentially suited to assessment in existing buildings:

- Operating energy, built up of:
  - Space heating, cooling and air treatment.
  - Electricity for other building services, especially lighting.
  - Water heating for normal building-related purposes.
  - In addition, energy used for other purposes needs to be identified and sometimes assessed. This will include occupier-related equipment, e.g. office equipment, process plant, catering kitchens; and energy supplied through the building but not used in it (e.g. for external lighting, signs and fountains). This user-related energy may also have knock-on effects onto the building-related energy use above.
- Recurring embodied energy in routine maintenance, replacement repairs, alterations, refits and refurbishments, and major interventions.

- Indoor environmental quality.
- Flexibility and adaptability.
- Control and controllability.
- Protection of materials
- Cleaning as it affects IEQ, materials life and loadings from use of undesirable chemicals.
- Neighbourliness (e.g. noise; night lighting; waste bin placement, smells and collection systems; traffic and parking).
- Manageability, including security.

7. NEXT STEPS

- Each of the categories of variables needs to have specific variables identified and units of measurements defined.
- More detail is required in defining the step by step methodology, and in separating the building design, user and management issues.
- Transparent linkages to design assessment methods should be developed.

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A technology policy for sustainable building*

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1. INTRODUCTION

It is well known that the built environment today is the main contributor to unsustainability of the natural environment, since it is the major consumer of natural resources, particularly the non-renewable ones, and also the main producer of waste and pollution. At the same time, it does not necessarily satisfy people's needs and expectations, nor does it assure a real economic growth and welfare. This is very much evident in undeveloped and developing countries where there is still a lot to do for social and economic wellbeing, but also in developed countries (Mega, 2000), where we need to be really concerned about natural resources depletion, environmental pollution, and social and economic lack of equity.

We do surely need to work towards a sustainable development; what it is still not so clear is how we can do this. It is a quite largely shared point of view that effective results can come from local initiatives, where the three key factors towards sustainability –environment, society, economy– are well known in the context of action and potentially can be better managed. Nevertheless, even acting at a local level, these initiatives have to consider the global level of a sustainable development –*think globally, act locally*-, because one of the main features of the sustainability concept is to highlight the fact that each anthropic action has effects both transversally world-wide and temporally between generations.

Many efforts have been made towards sustainability all over the world, mainly driven by the need for environmental protection and natural resources preservation, since this is seen as the most immediate risk for human survival, even before health and wellbeing. In a certain sense, we can say that the ecological principle has emerged as essential for pursuing sustainability. Consequently, any investigation towards sustainability has been carried out in the logic of ecology, showing how eco-development has not only environmental benefits, but also social and economic improvements.

In this light, we can affirm that physical aspects of sustainability have deserved a lot of attention so far, influencing both governmental policies –where any exist– and research commitments, while taking into little or no account its non-physical aspects. But, almost always and everywhere, non-material aspects of life are as important as material ones (Boyle et al., 2000), and today they can be considered even more essential. Moreover, it is the concept of sustainability itself that requires a wide and omni-inclusive approach, able to face complexity residing in reality when both physical and non-physical aspects are involved.

This situation demands something more than what has already been done, that is something that can enable us to go beyond a single vision of sustainability, thus challenging our competencies and abilities in the search for sustainable actions. Also in the field of

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construction and more in general building, we can notice, on the one hand, that acting towards sustainable building has been more and more recognised as necessary for global sustainability; on the other, that advancements in the field have been mainly made on the basis of an eco-development, not yet considering the multiple aspects involved in such action. Taking this as our starting point, we can now try to trace possible evolutions of sustainable buildings.

2. ADVANCEMENTS TOWARDS SUSTAINABLE BUILDING

It is right to remember that building plays a major role towards sustainability for many reasons (Hartkopf and Loftness, 1999). We must consider physical aspects, like building materials and components, construction processes, building use, re-use and/or refurbishment, and lastly demolition if necessary; as well as non-physical aspects, like the real meaning that buildings have for people, since they are where they spend most of their life –home and workplace– and as an entire built context they constitute the identity of urban spaces in which citizens can find their citizenship.

Concerning the physical aspects, many both practical and conceptual advancements can be acknowledged. At present, quite rightly attention is being posed on the embodied energy of construction materials, the potential for re-using and recycling materials and components, the bettering of their disposal when the building has to be demolished. With regard to building use, the main advancement is derived from the consciousness that a building consumes a lot of energy, and consequently money, right throughout the period of operation; thus many improvements have been done following the principle of resources efficiency, in terms of both reducing consumption and turning to renewable sources of energy.

Construction processes are then influenced by such an approach, aiming at choosing, and sometimes inventing, systems of construction able to minimise resources utilisation while optimising performances of materials, components and the whole building. The same point of view has also enabled the issue of re-using and refurbishing buildings to receive a major attention recently, highlighting that a building with a high durability and reusability has also a high long-term resource productivity (Kua and Lee, 2002). All this has led to investigate methods for measuring the “green” content and assessing the life-cycle of a building as objectively as possible.

Concerning non-physical aspects, advancements towards sustainability are less recognisable in the efforts carried out so far. One is certainly related to the positive effects induced on human beings by their wellbeing assured by the means of a healthier outdoor and a more comfortable indoor environment, which in the end are the very objectives of sustainable management of the physical aspects of buildings. Another can be seen in some attempts, often beyond the scale of the single building, aimed at re-qualifying the built environment, considering people also as a resource and directly involving them in processes of their own concern, believing that, otherwise, sustainability cannot be really achieved (Conte, 2001).

From these synthetic considerations, we can draw some useful elements to hypothesise paths towards the future of sustainable building. First of all, we must see the faults implicitly and explicitly included in the approach utilised up to now and the results it produced. Then, we can try to outline the terms of sustainability for building, using a wider, and possibly more effective, approach which considers many aspects of the problem. Finally, we can trace a possible line of action aiming at pursuing sustainability in the building field, trying to indicate what commitments need to be carried out.

3. A WIDER APPROACH TO SUSTAINABILITY

3.1 Faults, risks and challenges

The main thing to criticise within the approach utilised towards sustainable building until now is that of being run almost exclusively along ecological and energy conservation lines; but at present we know that eco-design has its limitations too (Roy, 2000). This approach, on the one hand, has permitted the such concerns spread widely among actors involved in the building process, which is positive and was certainly necessary at the beginning; but, on the other hand, it has focused almost all investigations, although significant, on solutions rather than on processes, thus not recognising the multiple and interrelated aspects of sustainability, and consequently, putting emphasis on physical aspects while neglecting non-physical ones, which, instead, require, as already stated, a lot of attention.

In some sense, it is as if we have not completely accepted the challenges posed by sustainability, and this has happened at different levels and for different actors in the building process. Architects and engineers have concentrated on green building design, mostly intervening on the building envelope and plants; producers have finally understood the possibility of profiting from eco-labelled products, even if not very diffused yet; constructors have perceived the usefulness of acting in the light of quality and durability of constructions; decision makers, when sensitive, have disposed different forms of incentives, mainly economic ones, for promoting green projects and the provision of energy from non-renewable sources.

At present we are working along an incremental development, going further step by step, making use of consolidated knowledge and tested technologies on which to base new solutions, and sometimes they are only re-interpretations of known solutions. In this way we ignore a fundamental aspect of sustainability, that is the inter-generation relationship, which suggests considering human needs which change with time, and which can only be foreseen with difficulty, as we have learnt from the past. In doing so, the risk is that of frustrating our efforts towards sustainability by not achieving satisfying outcomes. On the contrary, it is much more likely that if we act using a radical approach, we can reach the real objective of sustainability better, and in this light innovation is essential (Rennings, 2000).

3.2 Innovation and technology

For Western countries the crucial role, particularly the economic one, played by innovation and technology towards development is not new. For example, more and more often we see that innovation is a key for success in industries, which are more competitive when they innovate their product design. Innovation seems to be the key which can fit flexibility typical of complex processes, such as sustainability, and must be seen as a challenge (Vollenbroek, 2002). If we want to be successful in managing sustainable development, we must recognise the multi-level dimension of sustainability and the uselessness of finding specific sustainable solutions; instead, we must improve our behaviours, knowledge, skilfulness, trying to learn to face changing needs, acting at different levels, working with many actors.

Technology is also crucial in that it generates innovation. We only have to shift from a technology-driven to a society-driven approach, that is, be more aware of consequences across society of technological advancements (Coates, 2001). This is not at all easy, since we have behaved diversely so far, thinking and acting as if any technological advancement be a good thing per se and necessarily mean a form of progress. Thanks to the growing concern for

sustainability, now we share the consciousness that real progress depends on ourselves and we must drive technology towards what we need. This does not imply stopping any technological investigation, but rather it has to be intended as a stimulus in acquiring the ability to manage technology in a way that meets present needs without compromising the construction of future needs.

What emerges from these considerations is that, notwithstanding considerable efforts made towards sustainability, particularly sustainable building, and their significant outcomes, we lack the ability to use a multiple vision of it. Practically, we have not been able until now to produce innovation, essential for facing complex systems, and to improve technology at a sufficient level to really suit sustainable processes, rather than solutions. This seems to be basically due to having applied a reactive approach, which drives towards the future in an incremental way, rather than a pro-active approach, which on the contrary could drive towards the future in an innovative way. Then, it becomes important to trace some possible lines of action, trying to accept the whole challenge of sustainability.

4. PATHS TOWARDS THE FUTURE

4.1 Technology policy and alliances

When innovation is required, the best thing to do is to promote it in several ways. The aim is to stimulate the creation of ideas and their application to new products and services. Technology can be considered a tool for this, since it is able to support innovators, be they designers, producers or decision-makers. Sustainability requires acting at global and local level; it requires considering many factors and actors involved, and gives us responsibility for the future as never before. The question is whether we can, or cannot for certain, define something as sustainable, and the answer is that we really cannot, at least with our actual technical knowledge, because sustainability is an evolving concept, implying uncertainty, thus requiring technological systems to be more adaptable and changeable (Knot et al., 2001).

Thus, our main goal has to be that of improving our decision-making activity for innovation and technological investments, to make them more fruitful for sustainability. We need to face complex problems and manage flexibility, as already stated, so it is essential to work within a broad approach, considering applications both at general and specific level, interlacing many factors, sharing knowledge among actors. We need a technology policy, that is strategic decisions about building technology which can make us all work together effectively towards the objective of sustainable building. This technology policy must have the characteristic of involving many subjects, stimulating innovation, focusing mainly on quality rather than quantity, even when measuring performances, dealing with non-physical aspects as well as physical ones, using its feedback for learning, and constantly evaluating its outcomes.

A suitable path for this seems to be that of forming alliances based on technology development. Since one of the weakest points in present behaviour consists in the lack of knowledge transfer, particularly between researchers and producers and policy-makers, the best alliance can be between universities, industries and governments. This should favour the generation of a knowledge infrastructure, with overlapping areas of interest, and the emerging of hybrid organisations at the interface (Etzkowitz and Leydesdorff, 2000). Each part is requested to be pro-active in the approach, flexible in managing changing needs, and should carry out knowledge-intensive activities; while the alliance should promote innovation, incubating new firms as well, and concern itself with effective transfer of knowledge and technology advancements inside and outside the alliance.

4.2 Decision support and education

Knowledge emerges as the key factor, inviting reflection about what can be useful in operational terms for pursuing the goal of sustainable building. Knowledge characterises human activities and particularly design and decision activities. Thus, to refer to the building field only, we can recognise two figures in the process who have to act decisively on their knowledge: building designers –architects and engineers– and policy-makers. They both are solicited to make decisions, to do so they consider many factors, evaluate their consequences, explain motivations, convince and learn from other actors in the process. Therefore, actual improvements in technology, particularly information technology, can be used and further developed for supporting decision activities (Shim et al., 2002). This is not a new concept, but must be actuated in such a way as to produce new tools, more effective and efficacious than in the past, explicating the ability to actively participate into the decision process, stimulating self-learning and innovation.

Moreover, knowledge must be transferred between the parts involved in a process and also cultivated as an indispensable requirement of our actions. This requires paying attention to educational and training activities at all levels, and in the building field particularly of students of architecture and engineering courses and building professionals. In fact, students are the researchers, innovators, producers, technicians, professionals, decision-makers of tomorrow, as well as users of buildings; therefore they are the main cultural resource for future. We have great responsibility in equipping them to interpret sustainability, accepting its challenges, and to manage technology to guide decision-making under uncertainty conditions (Crofton, 2000). Sustainability must become a central theme of training programmes for professionals too, since it is an evolving concept and for this reason needs to be continuously re-interpreted. All this suggests a great effort must be made in changing the present educational programmes to make them more suitable to sustainability, and in this action the technology alliances stated above can also play an interesting role.

5. CONCLUSION

Any advancement towards sustainable building shows a force which is at the same time its weakness, that of being ecologically and resource-efficiency oriented. At present, what we have investigated more thoroughly and have been able to put into practice is green buildings and technologies; but it is not enough for sustainability, which is not only a question of environmental protection and preservation. It is time we enlarged our vision of sustainability, considering its multiple dimensions which introduce complexity and uncertainty in the processes to be managed.

We need a change in perspective influencing our present behaviour, shifting from a reactive to a pro-active approach, which seems to be able to face complex problems better and produce more suitable results. A key to succeed in sustainable building, as in other fields of development, is innovation as long as technology supports it. We can use innovation as a factor of competitiveness in all activities related to building, like design, production, construction, utilisation and so on. But we need to apply innovation to systems and processes, thus we must develop technology within a strategic plan, here identified in a technology policy.

A technology policy should characterise future investments of the parties involved, harmonising them in a synergetic effort. Scientific alliances based on technological development for buildings are essential for pursuing such objectives, while guaranteeing

flexibility and cultural advancements. Improvements in knowledge activities are needed, both for decision-making and technology transfer, and we can operationally work on this, producing effective decision support tools for building activities and innovating educational programmes in the building field. In this way, we are trying to face the real challenges posed by a sustainable development.

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The 2-liter Office Building for 2050

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1. DESCRIPTION OF THE BUILDING

The Rockwool International (RI) research centre tries to integrate the need for added office space, low heating energy (2-litre oil energy per m^2 per year) office building construction with architectural qualities, environment friendly design together with the optimal use of own products. The idea was to construct a building with sustainable qualities together with an optimal use of simple, but state of the art technology.
The focus has been on building lasting "passive" qualities into the building by combining environment friendly design, LCA-screenings of construction and technical installation choices together with a systematic reduction of heat loss through the building envelope.
In order to follow actual building performance it was decided to install moisture, temperature and CO_2 sensors in the building, making it possible to follow the indoor climate and thermal performance continuously. Finally it was decided to register all energy and material use during construction of the building, making it possible to follow material use and flow in actual terms. Actual data can be viewed online at http://www.rockwool.com.

2. EARLY PLANNING THOUGHTS

The new research centre was designed using LCA-thinking and from prior set goals:

- Minimising space heating demand to minimum half the Danish building code BR-95 requirement of 50 kWh/m^2/year for commercial buildings
- Minimising the environmental impacts from the building
- Securing a pleasant indoor climate regarding temperature, daylight and air quality by means of controlled natural ventilation
- Demonstrating the capacity of passive fire protection of the constructions
- Long life of the building
- Good quality of architectural design

The building was to be designed using "Manual in Environment Friendly Design" (Danish Association of Consulting Engineers. 1998) involving the making of an environmental scheme containing LCA-modelling of primary construction parts during the planning of the building project:

- LCA-screening of different of load bearing structures: Concrete, steel and glulam (glue laminate)
- LCA-screening of different of heating systems: Heating by electric panels and central heating with furnace powered by natural gas

Furthermore unwanted materials and construction elements were to be eliminated in the construction of the building. PVC-free wiring was preferred rather than traditional wiring. Solar panels were chosen for hot water supply and the building was to be ventilated by natural ventilation.

The work was to be finished with a Life Cycle Inventory analysis (LCI) of the whole building when the building was completed.

3. SCREENING LCA'S

3.1 Conditions

The screening LCA's were carried out in order to compare environmental impacts of different load bearing structures and heating systems.
At first three LCA-models of load bearing structures were considered: Reinforced concrete, steel and glulam. Later during the building project the construction was changed somewhat and it was found necessary to construct a 4th model.
The heating system of the building was modelled in two ways: Heating by electric panels or central heating with furnace powered by natural gas.

The LCA-screenings were all modelled using the EDIP-method (Wenzel, H. et al, 1997) and EDIP PC-tool (β-version) including a unit process database. The LCA-method is closely related to the ISO 14040-series. In the PC-tool data are "terminated" - calculated to elementary flows. E.g. the use of energy in processes and embedded in materials are terminated to primary energy (including precombustion). Material data missing in the EDIP unit process database were added from published literature (e.g. SIA D0123, 1995 & D093, 1997).

All data were accounted for by means of quantity (mass) with a cut off of 5 percent or included if known to be of environmental interest e.g. materials known to be very energy consuming in production or containing scarce resources. Windows, flooring and surface treatment like paint were omitted. They were assumed to be identical in each model and therefore without interest in the comparative analysis.
Data categories were limited to primary material and process energy (including precombustion) and air emissions: carbon dioxide (CO_2), sulphur dioxide (SO_2) and nitrogen oxides (NO_x).

The life of a building is described as a system consisting of four phases: materials, construction, use and demolition. In the case of the load bearing structures, the LCA models consisted of only three phases since the use phase was assumed to be identical in each model and therefore without interest in the comparative analysis.
In the case of the heating systems each of the LCA-models consisted of three phases: materials, use and disposal.

Different scenarios for the use of materials and different disposal scenarios were modelled in order to perform sensitivity analysis. This was to establish the significance of changes in the choice of material origin and in the form of disposal. E.g. the use of virgin metals was compared to the use of recycled metals and combustion with energy recovery of different materials was compared to landfill or combustion without energy recovery.
The scenarios were conducted with different degrees of reuse/recycling of the materials. The final choice scenario consisted of use of virgin metals in the materials phase and 90% recycling and 10% landfill in the disposal phase as believed to be the most likely disposal scenario of major construction parts in the future (Danish EPA, 1998).
Materials with embedded energy e.g. wood and cardboard are believed to be disposed of by combustion with energy recovery.
Allocation was mostly avoided by expanding system boundaries in the models. In case of allocation it was performed on the basis of material grade, e.g. recycling of steel.

In the heating system the significance of an increased/decreased need for replacement of materials and maintenance in addition to the lifetime of the systems was modelled.

3.2 Functional unit

The object of the LCA-screenings were the functional unit of the construction models:

A 6 meter cross section of the building consisting of load bearing structures and horizontal divisions

The functional unit of the heating system models was defined as:

Heating of the 2-liter office building in 75 years with a calculated total heating demand of 67MWh per year

3.3 Results

The results of the LCA-screenings of the structure models showed that the glulam model was preferable in a scenario where materials are not recycled or reused. This is not likely in a future disposal scenario.

The reinforced concrete model was found to be the least preferable in all scenarios.

The steel construction was changed during the project from the initial system with load bearing structures of steel with horizontal divisions of hollow concrete elements to a lighter steel/wood cassette system. The results demonstrated decreased environmental impacts from the steel "as built" model compared to the other models except in the data category carbon dioxide (CO_2).

The change in the steel construction type made a higher degree of future recycling and reuse of the materials (steel and wood) possible. The final results of the LCA-screenings of the structure models are displayed at the inventory stage in Figure 1.

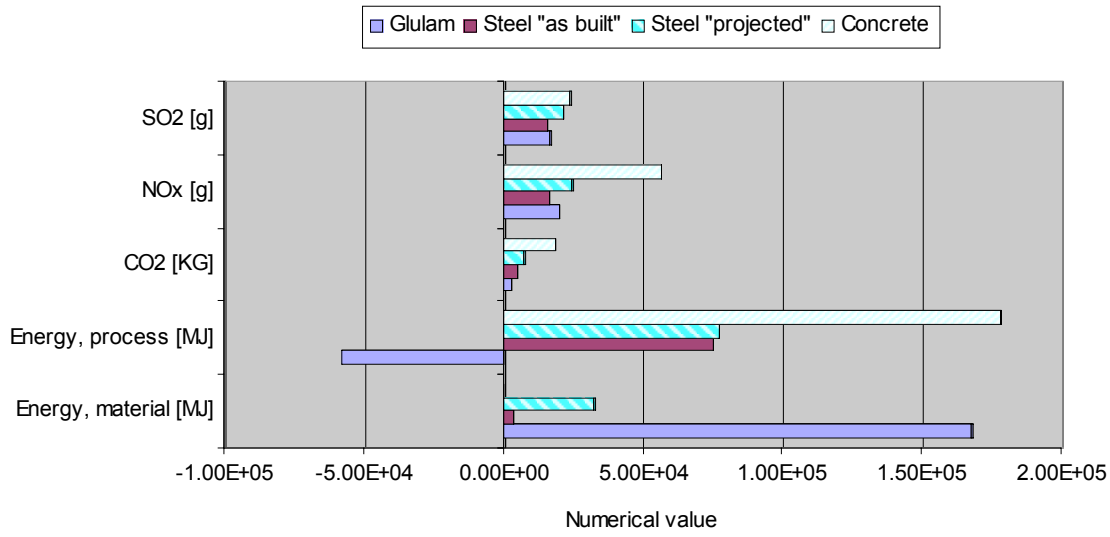

Figure 1 Environmental exchanges based on LCA-screenings of different types of load bearing structures in the 2-liter Office Building

The LCA-screening results of the heating systems are not displayed here due to lack of space but the results showed in all scenarios that central heating with furnace powered by natural gas was preferable to heating by electrical panels.

The steel/wood cassette system was chosen in favour of the reinforced concrete and wood systems and central heating with natural gas was chosen in favour of heating by electrical panels.

4. LCI OF THE 2-LITER OFFICE BUILDING

The work was finished with a life cycle inventory analysis (LCI) of the whole building performed as part of the construction process and modelled shortly after the completion of the building.

4.1 Goal and Scope of the LCI study

The goal and scope of the LCI study was to collect data and account for all significant product, material, energy and water consumption during the life of the 2-liter office building.

The functional unit of the LCI study was defined as:

The 2-liter Office Building with a life of 75 years

The life of the 2-liter office building was modelled in the EDIP PC-tool as a system consisting of four phases: materials, construction, use and disposal & recycling. The use phase was left empty in the model, as no data were available when the LCI study was carried out. Building performance during use was to be and is continuously monitored and displayed at the homepage of Rockwool International: http://www.rockwool.com.

System boundaries were initially set at materials and energy input and output needed for the construction of the main building, but the collection of data was extended to include materials used in the surroundings of the building e.g. drain installations since the building would not function without these installations. Modelling was otherwise performed as described previously.

4.2 Collection of building site and material data.

Delivery notes and weight slips from weighing at the construction site accounted for all materials used or scrapped during construction. In addition all consumption of electricity, water and fuel, oil and gas during the construction phase was accounted for.

4.3 Material sorting in classes

The different materials and products were sorted and aggregated; altogether 71 different product categories/material classes were used in the modelling of building.

5. LCI RESULTS

In the following key results from the LCI study is shown graphically.

In Figure 2, the negative impacts shown are the results of the energy recovered by combustion and saved by reuse of materials.

In Figure 3, the energy use directly on the building site is plotted. Please note the energy cost for heating the building site in winter. This could be saved with careful planning.

In figure 4, the material consumption is summarised. It is noteworthy that stone, gravel and bitumen use for roads and parking space are higher than the use in the building itself.
Even in a steel structured building, concrete still dominates on a weight basis.

In figure 5, the waste categories are summarised. Please note that the waste from clearing the building site is almost half the total waste.

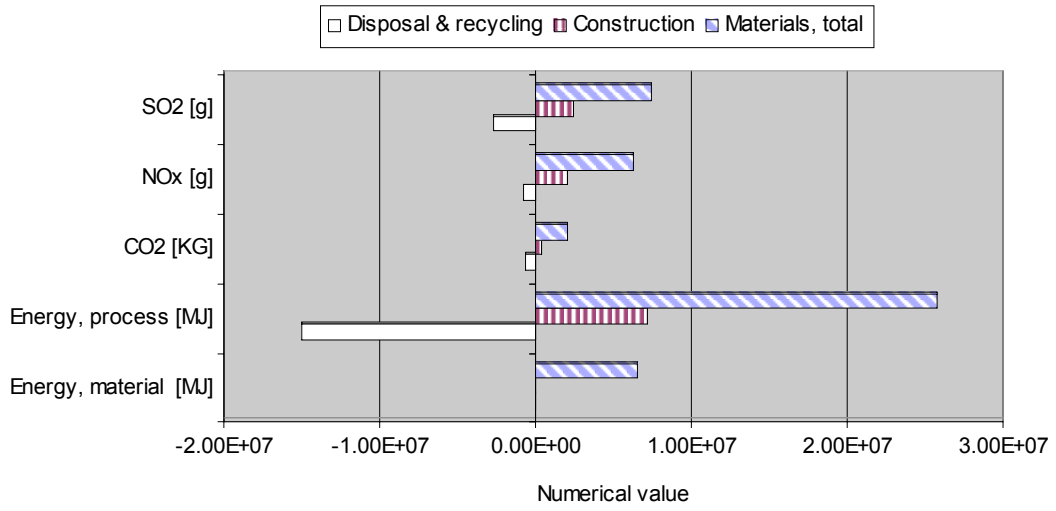

Figure 2 Environmental profiles of the different phases in the LCI of the 2-liter office building

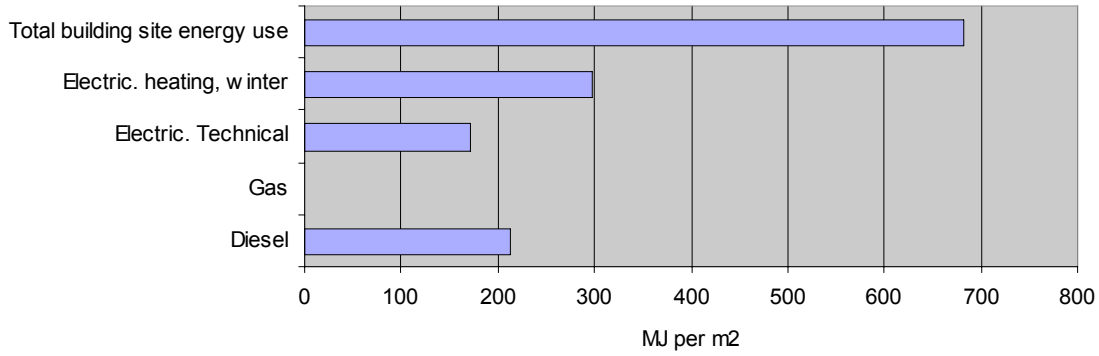

Figure 3 Energy used on building site during construction: machinery and electricity

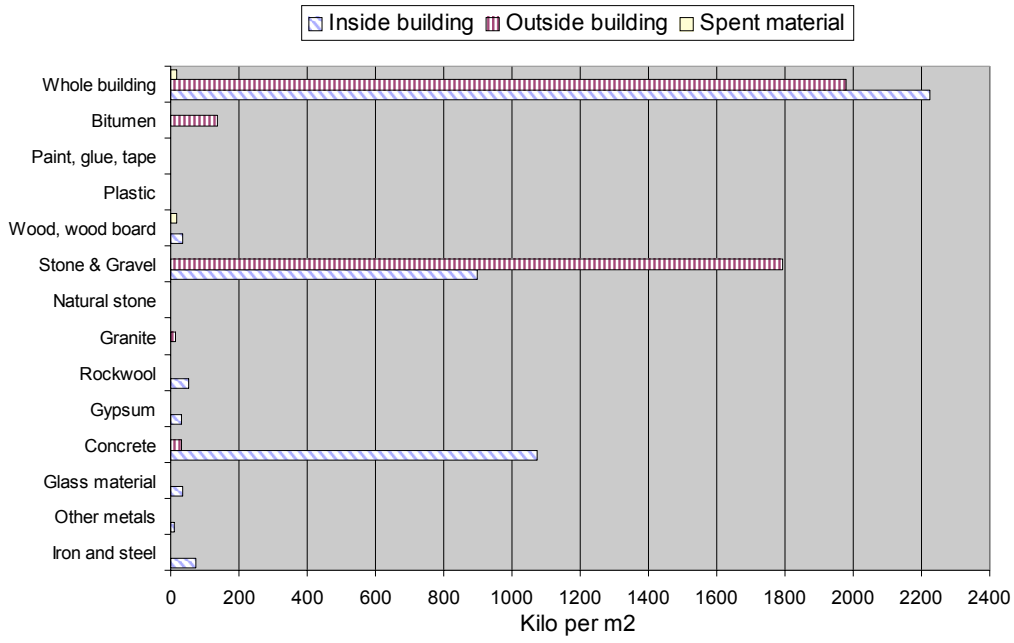

Figure 4 Material consumption inside, outside and consumed in kilograms per m^2

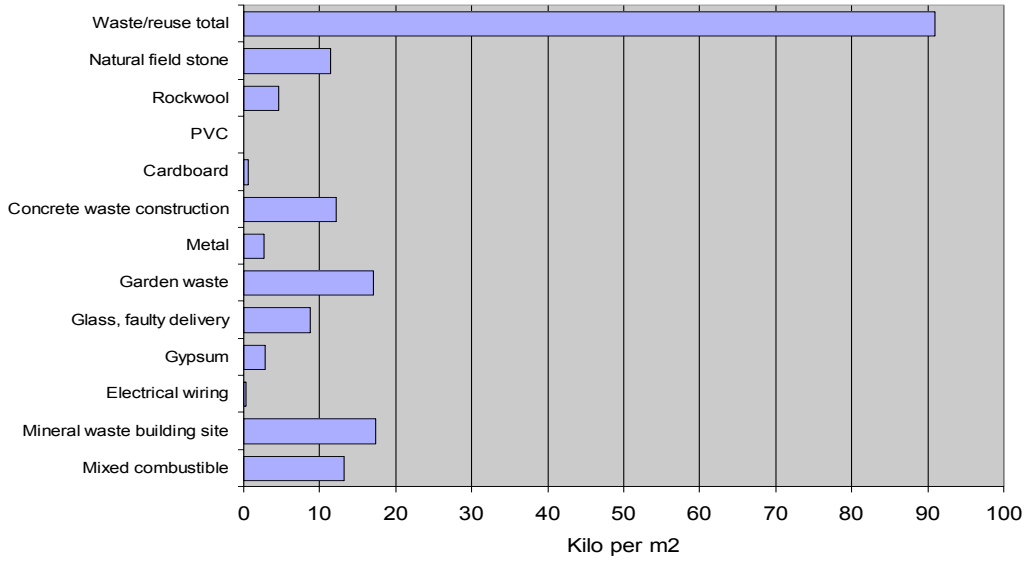

Figure 5 Waste from the construction of the building in kilograms per m^2 floor area

6. DISCUSSION

To implement "environment friendly design" early in the design phase is difficult because little is known of the building. On the other hand this is where the building sustainability performance is decided. From a sustainability point of view it is interesting to follow the energy use, as energy is believed to be the dominant environmental factor in the future. The energy use for construction compared with energy use during 75 years is shown in Table1.

Table 1 Energy use in liter oil equivalent per m^2, based on first year actual consumption

Energy used for building construction	161
Lighting energy 75 years (heat)	185
Computer electricity 75 years (heat)	202
Heating energy 75 years	285
Body heat from staff (60-130) in 75 years	23-50

On top of this the building must be retrofitted several times during the next 75 years. As an example, the retrofit of new glazing in old frames is estimated to cost additionally 13 liter oil equivalent per m^2 floor space - each 25 years. Another lesson is that as lighting and computers consume less energy and develop less heat in the future, the necessary heating energy will increase unless the building heating energy demand is reduced further.

7. CONCLUSION

By using environment friendly design it is possible to construct buildings with low embodied energy use together with low environmental impacts during use. It is quite feasible to produce affordable buildings of year 2050 performance with today's knowledge and materials.

For the future, sustainability for buildings means low embodied energy in building materials and construction and easy reuse/recycling of materials, without compromising durability, together with the lowest possible heat loss during use.

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Environmental Impact of Architectural Paints

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1. Introduction

The environmental problem, in the last decades, showed the need to employ materials of low impact to the environment. The public policies imposed environmental requirements on several activities, and the building construction is one of them. The regulations to control the emission of atmosphere pollutants have been increasing and the demand for less aggressive products to the environment has been growing as well.

Environmental protection agencies from the United States, Canada, Japan and the European community already imposed restrictions to the maximum VOC, which has been influencing the development of new products. Some American States have begun a process of adopting regional regulation on architectural and industrial-maintenance coatings, while in Canada the manufacturers are producing more environmentally friendly paints with reduced odor and VOCs. Therefore, the development of products with lower environmental impact has been one of the main research subjects in the paint industries. Significant changes were observed in the formulation, production and application of paints. Several technologies have successfully been adopted such as: formulation of products with high solid contents, reduction of aromatic solvents content in the paints, use of oxygenated solvents or production of powdered paints, change of solvent-based products to emulsion-based products, use of new coalescents or elimination of coalescing solvents and glycols in latex paints.

This paper presents the preliminary results obtained in a study whose objective is to investigate the environmental impact of architectural paints in Brazil. The results obtained will allow for a diagnosis of the VOCs emissions in paints in order to obtain national ecological indicators. These data will permit to give support to the paint industry in the optimization of paint formulations with lower environmental impact, and also to alert constructors and workers against the adverse health effects caused by VOCs emissions.

2. BUILDING CONSTRUCTION AND THE ENVIRONMENT

The macrocomplex of the building construction is also a generator of pollution and wastes. The activities during the construction phase significantly modify the environment. The activities in the site generate sound pollution, construction wastes, particulate matter and, in the case of painting products, the emission of VOCs, which is a serious source of atmospheric pollution. The

emission of VOCs from polymeric building materials in indoor environment has been studied by several researchers (Yu & Crump, 1998) (Tham et al, 2000) (Kasanen, et al, 2000) (Senitkova, 2000) (Yang et al, 2001). The studies show that the VOCs emitted by these finishing materials can cause adverse health effects. The indoors air quality is a relatively new problem in Brazil but intensely studied in Northern Hemisphere countries, where the number of air-conditioned buildings is very high. This emission is important for painters in buildings under construction because may cause occupational health problems (Sato et al, 2000) and, after their completion, for the residents in the initial occupation period. The emission from materials is usually continuous and may last many years, leading to symptoms of ìSick Building Syndromeî.

With globalization, the world is getting more and more competitive. The Brazilian companies are being pressed to reach international patterns. The quality subject revolutionized the building industry during the last decade and today the environment has risen above it in importance. The environment, safety and workers' occupational health are considered the paradigms of the 90ís. Besides the user's satisfaction due to the performance, durability and cost of a specific building product, today the environmental quality is also discussed. The selection will not be done based only on aesthetic criteria, durability or cost, but also on the environmental impact of a product.

In a near future, the ecological criteria will be added to performance criteria and cost. The reduction of environmental impacts in this sector could be used as an important tool for marketing. Even in Brazil now, many major paint manufacturers and raw material suppliers are introducing products with lower VOCs emission and toxicity to attract consumers.

3. VOC AND OZONE EMISSIONS

VOC is defined as being any carbon compound that participates in photochemical reactions, except for CO2, CO, carbonic acid, carbide or metallic carbonate and ammonium carbonate. The solvent based paints and the products used during painting emit aromatic and aliphatic hydrocarbons, hydrocarbons containing halons, ketones, esters, alcohols in the atmosphere, which contributes to the ozone formation, harmful to the environment. Hydrocarbon together with oxides of nitrogen (NOx), present in the environment, in the presence of solar radiation (UV) and heat reacts with each other to produce oxidizer compounds and ozone, responsible for the formation of urban fog, popularly known by "smog" (BREZINSKI). U.S. Environmental Protection Agency (EPA) considers ozone the main substance of " smog ".

According to this Agency, the chemical composition of the solvent influences the levels of chemical reactivity, producing different peroxide content or ozone. Solar radiation and heat also favors for the presence of this chemical species. The ozone concentration varies from year to year according to changes in weather and is formed especially in the summer when there are a lot of hot and sunny days. Ozone is an odorless and colorless gas found in the air we breathe. Each molecule is composed of three atoms of oxygen, one more than the oxygen molecule. This additional oxygen atom makes ozone extremely reactive.

The ozone occurs in two layers of the atmosphere and can be considered " good " or " bad " to health, depending on its occurrence in the atmosphere. When it occurs in the stratosphere (upper atmosphere) - 16 to 48 km (10 to 30 miles) above the Earthís surface it is considered " good " ozone. This type of ozone forms a protective layer that shields the Earth against the action of the sun ultraviolet rays (UV-b), harmful to the skin with risks of skin cancer. This ìgood" ozone is gradually being destroyed by manmade chemicals, such as the chlorofluorocarbons (CFCs)

coming from refrigerators, air-conditioning, sprays and also carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), halons etc.

The other ozone in the troposphere, at ground level, is considered the " bad " ozone, harmful to human health, fauna and flora, crops, and many other common materials. It is a key ingredient of urban fog. The troposphere extends to a level about 10 miles up, where it meets the stratosphere. The repeated exposure to the " bad " ozone may cause permanent damage to the lungs and a variety of health problems. Even the modest exposure to ozone can cause chest pains, nausea, headache, pulmonary congestion and also neurotoxic effects to healthy individuals. People with breathing problems like asthma, emphysema, and bronchitis have increased difficulty breathing when the air presents high levels of ozone.

According to EPA and the Brazilian National Environmental Council (CONAMA) the ozone is one of the main pollutants of the air and is used as a parameter for measuring air quality (AQI - Air Quality Index). According to the report ìAir Quality Conditionî of S,,o Paulo City in 2000, published by the Environmental Agency for the State of S,,o Paulo (CETESB) the ozone exceed the recommended Index Values (160(g/m3) for 65 days that year, which represents 17,8% of the year. January to April and August to December (274 days) are the critical periods for ozone production in the low troposphere and it corresponds to about 23,7% of the days in these critical periods. This report shows that there is a need to implement strategies to reduce VOCs emission that is a pollutant precursor of ozone.

4. ARCHITECTURAL PAINTS

Paints have four main constituents, the binder or resin, the inert fillers and pigments, the solvents or dispersant and finally, additives such as stabilizers, surfactants, and thickeners to provide modifications on their properties. The main products used for painting buildings are latex and alkyd enamel paints. The alkyd resin paints require high levels of petroleum-based solvents, usually 50 percent. The latexes are thinned with water but they still contain appreciable amounts of VOCís constituted by products to improve freezing resistance (glycols) and film formation (coalescents). VOCs are ingredients present in these products that evaporate during the application and drying process, and are responsible for paint odor and emissions of solvents in the atmosphere. Almost all-common solvents have a deleterious effect on the atmosphere, some besides the environmental impact also have neurotoxical effects on workers during painting work.

5. EXPERIMENTAL PROCEDURE

Latex and alkyd enamel paints produced by major manufacturers were collected from the consumer market. Their chemical characteristics and VOCís were analyzed.

5.1 Characterization of VOCs

An accessory specific to determine volatile compounds was carried out by analytical gas chromatography via headspace sampler, coupled to mass spectrometry (GC-MS) (SHIMADZU HSS-4A). The GC-MS is a current technique for analysis of solvents and VOCís determination (Simonsick, 1992) and the headspace analysis is recommended in cases where the sample can not be diluted with a solvent as in this study (Young, 1992).

5.1.1 Sample preparation technique. The emission tests were realized on liquid paint and on films exposed during 24 hours in a room with constant temperature of 23oC and relative humidity of

50%. The paint films were obtained by applying the liquid paint on a Teflon plate with a film applicator (wet film thickness 600(m). After the exposure, the films were separated from the Teflon plate. The VOCs emitted by the liquid paint and by the films were separated in the gas chromatography column and then identified by mass spectroscopy using the following computerized library searches: NIST 107, NIST 21 and WILEY 229.

5.1.2 Chromatografic conditions
30meter x 0,25mm DB-5 Column
Oven: 60oC(2min hold) 10oC/min 250oC/10min
Injection volume: 0,4 mL, via headspace analysis
Sample without dilution and internal standard

5.2 Basic Composition of the Paints
The samples were characterized by chemical methods, adapted from ASTM-D 3723.

6. RESULTS
Table 1 shows the identification of the main compounds contained in the paints, by GC-MS technique.

Table 1 Compounds emitted by alkyd enamel and latex paints

Paint Sample	Compounds	Proportion in VOCs [%]
Alkyd enamel		
	2- Butanone (Ethyl methyl ketone)	
	2-Ethoxyethanol	
	1,1,3-Trimethylcyclohexane	
	1,2,4-Trimethylcyclohexane	
	1-chlorooctane	
	1,2-Dimethylbenzene	
	1,2,3-Trimethylcyclohexane	
	1-ethyl-4-ethyl-,trans-cyclohexane	
	1,4-Dimethycyclooctane	
	n-Nonane	
	5-Methyldecane	
	Cyclohexanepropanol	
	1-Decene, 2,4-dimethyl	
	3-ethyl-2-methylheptane	
	2-Butyl-1-octanol	
	4-Methylnonane	

1,3,5-Trimethylbenzene
1,2-Dimethyl-ciclooctane
1,2,3-Trimethylbenzene
n-Decane
4-Methyldecane
n-Undecane
Others
1.97
<2
2.56
<2
6.01
8.99
<2
1.76
8.13
13.52
<2
4.75
7.49
6.01
9.54
6.24
4.97
<2
4.45
10.59
2.05
3.40
-

Latex
Acetaldehyde
Ethyl alcohol
2-Propanone
Hydrazine
Acetic acid ethyl ester
11.0
28.7
4.5
3.6
1.2

According to this analysis the solvents of alkyd enamel paint is usually a mixture with more than 60 compounds. The identification was done only on compounds with higher proportions. Some of

them, in spite of their low proportion in the sample, are considered hazardous air pollutants and present toxic and irritating characteristics such as the glycol ethers, ketones, aromatic hydrocarbons and chlorinated hydrocarbons. This latter compound was identified in the alkyd enamel paint but is not considered a substance usual in paint solvent; the mass spectra were identified by library searching interpretation but they should also be checked by more accurate identification.
Films obtained after 24 hours of exposure, in ambient with controlled conditions, show chromatograms with much lower concentrations in solvents; for alkyd enamel samples and for latex paint only some solvent residue is observed.
Table 2 presents the health effects caused by some compounds according to the National Institute for Occupational Safety and Health (NIOSH).
Table 3 shows the characteristics of the latex and alkyd enamel paint shown in the chromatograms.

Table 2 Effects of some compounds emitted by the paints
Substances
Health Effects
Exposure Limit

Ethyl methyl ketone
Irritation eyes, skin, nose, throat; cough, dyspnea, pulmonary edema; blurred vision etc
NIOSH Rel.
C 0.2 ppm

p-Xylene
Irritation eyes, skin, nose, throat; excitement, incoordination, nausea, abdominal pain etc
NIOSH Rel.
TWA 100ppm

Hydrazine
Eyes, skin, respiratory system. Central nervous system, liver, kidneys
Ca C 0.03 ppm (2hour)

1,2,3 -Trimetylbenzene
Irritation eyes, skin, nose, respiratory system, hypochromic anemia, headache etc
TWA 25ppm

1,3,5-Trimetylbenzene
Irritation eyes, skin, nose, respiratory system, hypochromic anemia, headache etc
TWA 25ppm

2-Ethoxyethanol
In animals: irritation eyes, repiratory system; blood changes; liver, kidney, lungdamage etc
TWA 0.5ppm

n-Nonane
Irritation eyes, skin, nose, throat; headache, confusion, nausea, tremor, incoordination; chemical pneumonitis etc

TWA 200ppm

n-Hexane
Peripheral neuropathy, neurotoxicity
50 ppm

Acetaldehyde
Risk of conjuntivitis and irritation, possible human carcinogen
TWA 200ppm

Table 3 Characteristics of the paints

Paint Sample	Volatile content [%]	Resin content [%]	Pigments [%]	VOCís [%]
Alkyd enamel	41	41	18	41
Latex	58	15	27	-

The results obtained on films with 24 hours of exposure show that this period is sufficient to eliminate almost all solvent present in the paint film. However, it is necessary to confirm this result by applying the paint on a substrate normally used in building constructions to confirm these data.

6. CONCLUSIONS

The study showed that a wide range of VOCs can be emitted by the Brazilian architectural paints. These products are important sources of VOC emissions on buildings under construction.

The VOCs of paints can cause adverse effects on the environment besides workers' occupational health.

The development of voluntary labelling schemes by the paint industry sector, Brazilian government legislations and data-base of VOC emissions from the paints and other polymer building materials will further strengthen the market demand for low-emitting products, that is:

more environmentally friendly paints with reduced odor and VOCs.

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The Development of a Framework for Assessing Client Demand and Capacities for the Implementation of Environmentally Sustainable Buildings

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1. INTRODUCTION

The economic argument for environmentally sustainable buildings is increasingly supported by building case examples and seen as a potential rationale by which the environmental performance of the property industry can be improved. A rational market assumption is that evidence of profitability will lead to investments for environmentally sustainable buildings by construction clients through attributing value to improving the environmental performance of their buildings and will therefore generate demand. However there is little evidence to indicate that client demand is being altered. Although the need to reduce this seeming imbalance between demand and supply is recognised (Keeping 2000; Productivity Commission 1999), the effectiveness of attempts to do so are hindered by anecdotal evidence of the nature of market demand in the commercial property industry.

Demand for buildings in the commercial property industry is largely derived demand. An understanding of the complexity of client demand for environmentally sustainable buildings therefore needs to be considered from the wider perspective of their organisational and managerial processes within which critical decisions for integration in their property portfolio are made. Research is therefore needed to gain a more comprehensive understanding of what is demanded, what markets exists and the underlying factors that can help set the requisite conditions for their creation from the perspective of owners, investors, developers and tenants. Furthermore an understanding of their existing organisational capacities in relation to this demand is also required. This will assist in identifying directions as to what and how these can be developed in order to advance the implementation of environmentally sustainable buildings in the Australian commercial property industry.

2. INNOVATIONS IN ENVIRONMENTALLY SUSTAINABLE BUILDINGS

Integrating environmental sustainability with economic and social objectives in building projects requires a re-evaluation of the underlying values and assumptions governing criteria that

presently guide building inception, design and construction, use and disposal. Coupled with this is a need to redefine and redesign existing products and/or services, techniques and processes in building development and management. Innovations in building production, based on the principles of environmentally sustainable buildings, are therefore required to support this necessary shift in conceptual thinking and practice (Cole 2000; Hawken et al 1999). The concept of innovation infers that an idea, product, service, system, policy, program or process of production is perceived as new to an organisation (Damanpour 1987; Zaltman et al 1973). Innovations in the concept of environmentally sustainable building in this research is defined as 'any ideas, products and/or services, techniques, systems, tools and/or processes of production and administration, perceived as new, applied to any aspect of building production such that it directly or indirectly generates measurable environmental, economic and social benefits in building performance'. Innovations in environmentally sustainable buildings can therefore take many different forms and occur at various levels.

Given uncertainty as to the expected levels of performance and the benefits that environmentally sustainable buildings can generate, the prevalent trend in the markets is a preference for incremental improvements in the form of green product or process innovations. However there is increasing recognition that successful performance entails a shift towards system innovations and integration. In line with this is also a growing realisation that the potential environmental, economic and social effects of environmentally sustainable buildings are broad (Heerwagen 2000). Its effects extend beyond the realms of technical and project performance to organisation-wide improvements in product and process innovations.

Although environmentally sustainable buildings can potentially enhance an organisation's capacity for innovation and contribute to long-term strategic benefits, there is anecdotal evidence to suggest that organisations are developing relevant capacities, resources and market strategies that in turn can create demand and broaden markets for more radical innovations. Hence, to maximise the cost reductions and value added benefits that can arise from environmentally sustainable buildings, innovative changes in organisations are required. While innovations that integrate economic and environmental performance can enhance an organisation's competitiveness (Porter and Van Der Linde 2000), it is suggested that organisational inertia hampers progress towards the implementation of environmentally sustainable buildings (Cole 2000; Hawken at al 1999).

3. NATURE OF CLIENT ORGANISATIONS

There is general consensus that the production of environmentally sustainable buildings is inhibited by a 'vicious circle of blame'. It describes a continuous cycle where a lack of demand for the concept by investors, developers and users constrains supply by contractors which further perpetuates a lack of demand (Keeping 2000). This can be attributed to a property industry that is characterised by suppliers and users with conflicting interests, values and objectives. This conflict also extends to within construction client organisations where the demand for property projects and the type of project typically arises from the differing needs and interests of its various primary businesses or groups. Understanding the nature of demand for environmentally sustainable buildings therefore requires not only an understanding of the attributes of various client types but also the complexity within client organisations.

There is a wide range of client types in both the private and public sectors and various approaches have been used to categorise them. However a useful framework in the context of environmentally sustainable buildings is one based on the client's project interest. Owners, developers, investors, tenants and the nature of their stake, in terms of the type of risks, costs, value or timeframe in property development and management, are commonly cited as a constraint on the integration of environmentally sustainable building products and processes (Bartlett and Howard 2000; Bordass 2000). The principles and attributes of environmentally sustainable buildings that appeal to these groups in the market will therefore differ along with expectations of the benefits and the level of performance that can be achieved in a given project. An explicit consideration of their stake in development and management decisions is therefore needed.

4. FACTORS INFLUENCING CLIENT DEMAND FOR ENVIRONMENTALLY SUSTAINABLE BUILDINGS

Factors affecting client demand and ability to implement innovations in environmentally sustainable building that emerged from a review and analysis of the literature are categorised below.

4.1 Property and Strategic Organisational Performance

Client organisations' requirements for commercial property have been limited simply to housing people and production (Eul 1994). Aside from the provision of the appropriate form of space to meet operational objectives, building operational performance is usually not considered a high priority. This narrow view of buildings as products or ends largely ignores the potential of buildings as a means to enhance organisational performance. This hinders the realisation of mutually reinforcing cost and value added benefits that could result from the alignment of organisational and building performance. It can therefore be seen that client demand for environmentally sustainable buildings in their property portfolios is dependent on this integration.

Property impacts on an organisation's business through its customer interface, work environment and means of service delivery. An increasingly competitive global environment has seen a shift to the view of property as a strategic resource the management of which can support an organisation's corporate mission, business aims and potentially contribute to shareholder value, corporate competitiveness and improvements in strategic organisational performance (CREAM 2000). However, a recent survey conducted by the Property Council of Australia found that when compared to the UK and USA, there is a lower penetration of strategic property management strategies, policies and tools in Australia. Property is managed to maximise returns and to provide services to support business objectives over and above adding value to business or the provision of cost effective facilities. However, the same survey also concluded that Australian organisations are more likely to own their property when compared to the UK and USA (CREAM 2000). Given that property costs are a greater proportion of an organisation's annual operating costs, there is untapped potential to generate client demand for environmentally sustainable buildings.

4.2 Environmentally Sustainable Buildings and Strategic Organisational Performance

Management literature marks a growing emphasis on the strategic benefits that can accrue to environmentally innovative organisations from the integration of environmental sustainability

principles such as resource efficiency, waste reduction, pollution prevention and habitat restoration in organisational activities (Porter and Van der Linde 2000; Hart 2000). Von Weizsacker et al (1997) for example provide numerous examples where this integration has been shown to generate profitability, productivity and competitive advantage for organisations. Only recently are innovations in environmentally sustainable building seen as a compatible means to enhance an organisation's sustainability and environmental performance. This is evident in an emerging number of building case studies driven by organisations with an environmental sustainability agenda in their management. Well known examples include the ING bank in The Netherlands and the National Audubon Society Headquarters in New York. The peripheral role of property in organisations, which is further complicated by the definition and interpretation of environmentally sustainable buildings, has led to a more elusive understanding of its contribution to business.

In addition to economic benefits that include cost savings and risk reduction, environmentally sustainable buildings can also generate a number of direct or indirect social benefits such as improved public image and stakeholder relationships in the marketplace and technical benefits that include product and process innovation which are compatible with and reinforce critical success factors that define organisational performance (Heerwagen 2000). Environmentally sustainable organisational culture is seen as necessary to complement and maximise the wide-ranging effects of sustainable buildings that can include the development of environmentally innovative capacities within the organisation. The potential contribution of environmentally sustainable buildings to organisational sustainability, as perceived by clients, developers, investors and tenants, is therefore a significant factor in the creation of markets and a necessary basis for understanding the nature of its demand. A more explicit alignment of environmental sustainability, environmentally sustainable buildings with strategic performance and benefits arising from their interrelationships is required to foster market demand.

4.3 The Building Development Process – Project Inception

An integrated approach to the building development process is widely recognised as the means by which to fuse environmental, economic, social and technical criteria in the delivery of environmentally sustainable buildings (PCA 2001, Reed and Gordon 2000). There is consensus that the wider benefits of environmental building performance are maximised if sustainable building objectives are identified and incorporated by clients very early on in planning and development, evaluation and project definition.

Early integration of sustainable building objectives in broad scale decisions for example the build/no build decision, site selection and planning, or design team selection is needed. These are potentially the most environmentally significant factors and can greatly affect the capacity for integration in successive phases of the building delivery process. This should consequently improve the building's environmental performance over its life cycle and as well as its broader impacts. Furthermore, it is suggested that the costs for environmentally sustainable buildings increases if incorporated in latter stages of building development after a number of critical pre-design decisions have been made (Reed and Gordon 2000). However the implicit assumptions and criteria governing these key decisions, from a wider organisational perspective in which owners, investors, developers and tenants first recognise and consider an idea to build or refurbish, are rarely examined. The decision-making framework that links development

decisions for projects with decisions at the organisational and business levels therefore influences the nature of the demand for environmentally sustainable buildings.

4.4 The Australian Commercial Property Industry

The commercial property industry is predominantly driven by financial considerations of initial capital costs and returns on investment in decision criteria and long term planning that typically do not span beyond five years (PCA 2000). This short term view and preference for cost efficiency has led to a lack of emphasis on life cycle costs such as operational and maintenance cost components or value added benefits such as enhancing workplace productivity in the asset management process. Furthermore, infrequent use of property performance benchmarking, computer-based property inventory systems or ongoing property performance management in organisations has resulted in a lack of information structures for evaluating performance and decision making for property in the first instance (PCA 2000).

Demand for environmentally sustainable buildings in the commercial property sector is highly susceptible to changes in the business environment. Characterised by corporate downsizing, changes in corporate structures, reduced business horizons and alternative work practices, the last decade has seen the emergence of cost reduction, efficiency and value for money as principal objectives of property. While the need for space restructuring and rationalisation associated with these organisational changes provide an opportunity to challenge entrenched views of operational needs, there is also an increasing propensity for organisations to be more risk averse. Although the ability to integrate environmentally sustainable building practices is maximised in new projects, new development, relocation, land purchasing, they are infrequent and often considered 'one off' initiatives, the potential for environmentally sustainable buildings therefore lie in the adaptive reuse of buildings and integration into existing portfolio management in organisations. There is however only anecdotal evidence to support the integration of environmental with economic performance criteria in commercial property. A recent study by the Productivity Commission (1999) on the environmental performance of commercial buildings in Australia indicated that environmental performance, when compared to labour and capital, is a low priority for businesses. Whilst the cost and value added benefits of environmentally sustainable buildings are not adversarial to industry requirements, their compatibility with industry changes, for example the need for greater flexibility and adaptability, is not yet realised and therefore it acts as a hindrance to business and constrain demand.

4.5 The Market

While there is suggestion of emerging client demand and markets for environmentally sustainable buildings in the Australian commercial property industry (PCA 2001), there is also contradictory evidence to indicate that there is negligible demand (RAIA 2001). There appears to be only anecdotal evidence as to what is demanded and what markets exist for innovative products and/or services, techniques, systems and/or processes of production and administration. It appears that price competition and preferences for traditional value attributes such as aesthetics, location and function still dictate the commercial property market.

5. ASSESSING CLIENT CAPACITIES AND THE NATURE OF DEMAND FOR ENVIRONMENTALLY SUSTAINABLE BUILDINGS: A FRAMEWORK

A preliminary field survey of a small sample of owners, developers, investors, tenants and property consultants in both private and public sectors has been undertaken to ascertain their perspectives on the demand for environmentally sustainable buildings in the Australian commercial property industry. The purpose of the investigation is:

- To explore and identify principal factors that restrict or enhance client organisations' demand for and ability to implement innovations in environmentally sustainable buildings.
- To identify indicators that enables an assessment of client organisations' capacities and progress towards the integration of environmentally sustainable building practices in property developments and managed portfolios with respect to market demand.
- To elicit the innovative capacities that client organisations need to develop to create a culture more conducive to the implementation of environmentally sustainable buildings in the property industry.

From the literature presented in section 4 and the preliminary field survey, some key findings are summarised:

- Property development and portfolio management are not typically integrated with strategic planning and decision-making processes in client organisations. The short-term objectives associated with the business cycle and organisational change dictate a building's life cycle in the commercial property sector. Outsourcing property management, the lack of property performance measurement, benchmarking and ongoing assessment currently contributes to this lack of integration.
- Despite emerging recognition of the contribution environmentally sustainable buildings can make to cost savings primarily in the form of energy efficiency and waste reduction, there appears to be a lack of commitment of financial, human and technical resources to environmental sustainability (e.g. investment in environmental management and performance assessment).
- Clients increasingly perceive that environmentally sustainable buildings can contribute to human resource development (e.g. retaining and attracting high quality and highly skilled employees) and their organisations' capacities for innovations in environmentally sustainability to create competitive advantage. However there appears to be a lack of environmentally innovative strategies applied to property and a lack of research and development in the concept to foster the development of the relevant in-house knowledge and skills to implement the concept.
- The integration of environmental sustainability with organisational cultural change and business operations can contribute to the implementation and successful performance of environmentally sustainable buildings. Top-level managerial leadership and commitment can support integration of the concept at the organisational level.
- Environmental performance criteria, when compared to capital and return on investment, are a low priority for clients in broad scale decisions at project inception for commercial property development. The lack of integration in decision making is also influenced by a lack of investment in research on environmental innovative alternatives; lack of managerial commitment; lack of in-house environmental expertise and experience in project management; late engagement of consultants in the delivery process; risk averse nature of property projects; lack of building environmental assessment and feedback for continuous improvement; already established building development procedures and delivery mechanisms (e.g. procurement procedures in government departments).

- An overriding perception in the Australian commercial property industry is that environmentally sustainable building is a niche market which to date has primarily focused on technologies and energy use. Furthermore, supply is constrained by a lack of cost information as to what price premiums clients are prepared to pay for innovations in the concept and demand is inhibited by little evidence as to the concept's ability to provide competitive advantage.
- Government regulations, policies and industry initiatives intervene to inhibit or enhance the potential ability of client groups to profit and create a competitive advantage in the environmental sustainability of their property holdings. The general consensus in the industry is that there is presently little regulation and few demand driven strategies or commercial incentives to create markets for environmentally sustainable buildings.

Table 1 illustrates a number of factors affecting innovation in environmentally sustainable buildings with potential indicators that can be used to assess client organisations' capacities and resources, to evaluate whether these are consistent with driving demand for the concept and to facilitate the monitoring of progress in the development of capacities over time to support market transition. Table 2 below illustrate a number of significant innovative capacities that client organisations need to develop to create a culture more conducive to the implementation of innovations in environmentally sustainable buildings in the property industry.

Table 2 Innovative capacities for the implementation of environmentally sustainable buildings

- Capacity to gather and process information and develop knowledge and skills in environmentally sustainable building
- Capacity for research, development and experimentation
- Capacity for integration of environmentally sustainable buildings with core business
- Capacity for managerial leadership and commitment
- Capacity to invest and commit human and technical resources to environmentally sustainable building projects
- Capacity to integrate building development process and systems innovations
- Capacity for continuous improvement and learning
- Capacity to market and diffuse environmentally sustainable building practices
- Capacity to assess and respond to changes in the property industry and markets for environmentally sustainable building
- Capacity to promote industry and government action and define new types of relationships with regulators and industry organisations

Brazilian experience in recycling steel slags in civil construction: discussion and methodology proposal

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1 INTRODUCTION

The waste generated by different economic processes constitutes the main source for environmental degradation. The environmental legislation currently available in Brazil, involves: (a) establishing the maximum limits for atmospheric emissions and effluent treatment; (b) establishing strict procedures for classifying and disposing wastes in dumpings. These measures end up generating additional costs both for producers and governmental organisms.

Two strategies have traditionally been adopted in recycling steel slags: (a) steel industries' strategy, and (b) materials researchers' strategy. The strategy adopted by the steel industries, in many cases, has been selling or donating these slags. This approach is relatively efficient and solves the small wastemaker's problem but, as a limitation, presents deficiency in controlling the form for its use (which may even result in environmental accidents and health problems on the part of the user) and flaws in the utilization process (which may generate a negative image, impairing the expansion and consolidation of the market). It does not seem to be the strategy to be followed by the great generators, as is the case of steel industries.

The strategy adopted in academic research has concentrated on the replacement of traditional materials by materials with similar properties and smaller price. These researches are usually developed with little or no participation of the enterprises generating slags or of the final users and, with rare exceptions, are hardly ever used. As a consequence, the results in terms of environmental preservation and economic-social efficiency are very incipient and do not allow for potencialising the advantages of slag recycling.

This article presents a revision of blast furnace slags recycling experiences in civil construction in Brazil. Finally, from the new environmental preservation and market paradigms, some of the main conditioners for the development of new markets for recycling steel slags are evaluated.

2 PRESENT PHASE AND PERSPECTIVES FOR STEEL INDUSTRIES TO RECYCLE SLAGS

2.1 Recycling of ground granulated blast furnace slag as admixture to cements

Since 1952, the main way for recycling blast furnace slags in Brazil is its addition to cement (BATTAGIN; ESPER, 1988). This alternative, however, is not enough to consume all the slag generated in the internal market, being that, from approximately 5 million tons of basic slag annually produced in Brazil (IBS, 1995)[1], about 3 million are incorporated to cement (MARQUES, 1994). As a result, blast furnace slag stocks are growing at cement production plants (Table 1). These stocks must be treated as steel industries environmental liabilities in their environmental accountancy and demand actions to search for new alternatives for recycling blast furnace slag, especially considering some steel industries expansion projects for the next years.

Table 1 - Estimated blast furnace slag stock, in 1998 (in 1000t) (LITTLE&SETEPLA, 1999)

Enterprises	Plant	Cement producers
CST	0	2000
USIMINAS	1500*	2000
AÇOMINAS	0	2000
CSN	0	4700
COSIPA	0	1000
MANNESMANN	450	____
BARRAMANSA**	150	____
TOTAL	2100	11700

*put in the dumping area

** blast furnace slag stock no longer operating

The case of acid slags is a little more critical. Brazil is estimated to annually produce about 800 thousand tons of acid slag[2]. As these slags are less soluble and therefore hydrate more slowly than basic slags (JOHN, 1995). For this reason, they are not employed in the cement industry yet. Some researches carried out by Brazilian Portland Cement Association (ABCP) point to the possibility of using them as pozzolanic admixtures[3] to cement.

2.2 Blast furnace slag recycling in the slag cement production[4]

The slag cement production was the first form of slag recycling as hydraulic binder, which appeared about 40 years before the addition of slag to clinker. It was probably Emil Langen, director-chief of Friedrich-Wilhelm Iron and Steelworks, in Troisdorf, Germany, who, in approximately 1862, first produced slag cement (SMOLCZYK, 1980), adding hydrated lime to ground granulated slag.

In Brazil, nothing has been mentioned about employing this type of cement in comercial scale. In 1941, Ary Torres presented a proposal for an ABNT[5] Standard which included three categories of slag cement with hydrated lime: (a) *slag binder with lime*, for mixtures with more than 70 % of lime; (b) *metallurgic lime*, for contents lower than 70%; and (c) *sulphated metallurgic cement* with slag, calcium sulphate, hydrated lime or clinker.

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[1] Ammount estimated as from IBS data (1995), by adopting an average amount of 300 kg of basic slag per pig iron ton and a ratio pig iron production / steel production of 0.95.

[2] Amount estimated as from IBS data (1995), by adopting an average amount of 180 kg of acid slag per pig iron ton (SOARES, 1982).

[3] Pozzolans are silicate or silicate-aluminate glasses which demand a Ca source to get hydrated, thus forming C-S-H.

[4] In this work, the expression *slag cements* identifies slag cements **without** clinker. The expression *cements **with** slag* identifies cements with slag addition.

[5] Brazilian Association for Technical Standardization - ABNT.

Despite the virtual absence of comercial exploitation, many researches have been carried out with slags activated with different chemical compounds. CINCOTTO; JOHN (1990) present results from some slag cement studies. JOHN (1995) studied the activation of basic slags by sodium silicates, obtaining high mechanical resistances in the first few hours. SILVA (1998) proved the benefits of employing thermal curing for activating blast furnace slag cement, managing to reach resistances above 50MPa at 1 (one) day of aging, adopting 6.5h curing cycles and maximum curing temperature equal to 60°C. This technology can also be adapted for the acid slags case. Some concrete and glass fiber reinforced concrete prefabricated manufacturers have now been showing interest in technology transfer research and actions related to blast furnace slag activation.

2.3 Slag cement for specific applicactions

Slag cements disappeared from the market mainly because they presented relatively low mechanical resistance at first agings and failed to present other competitive advantages concerning cement other than lowering the price. These limitations have now been overcome by the significant advances in scientific knowledge on building materials. For example, in Brazil there is technology for producing slag cement which, in 24h, reaches mechanical resistances higher than those of ordinary cement after 28 days (JOHN, 1995; SILVA; 1998) and which can be extended to acid slags. This technology can be easily adapted for sprayed concrete - with important applicactions in tunnels – and concrete prefabricated manufacturers. CAMARINI's results (1995) also prove that cement containing high slag contents are more adequate for thermal curing.
In spite of this, the mere sale of these cements in the market is not advisable, due to the low technical level of consumers in general and also due to the difficulties in distributing a new type of cement in such a vast market and with so many consolidated suppliers. Therefore, one of the alternatives for flexibilizing the market is to develop and produce binders for specific applicactions, especially those in which the ordinary cement cannot be applied or presents technical and economic disadvantages.

AGOPYAN; JOHN (1993) show it to be possible to formulate slag cements which, contrary to common cement, may be reinforced with vegetal fibres. At present, some prefabricated concrete and glass fibre reinforced cement manufacturers have been showing interest in technology transfer research and actions related to activating blast furnace slag. Many other alternatives for specific applications of slag cements can be developed through scientific research allied to an adequate market opening strategy.

2.4 Recycling of ground granulated blast furnace slag as an addition to concrete

The cement industry uses slag for partially substituting clinker, whose production cost is usually less than US$ 10/ton. As the slag has to be conveyed to the cement industry and submitted to drying and grinding (significantly more difficult to accomplish than with clinker), it hardly ever reaches more than US$ 6/ton, approximate value reached in many contracts. Besides this financial limitation, the dependence of steel industries on a single consumer constitutes a serious strategic defficiency.

The blast furnace slag comercialized as mineral addition to concrete could reach values close to US$ 80/ton. This commercial modality is adopted in the USA, where the sale price for ground slag is approximately 80% of the common cement price. MARQUES (1994) showed the technical viability for this form of employment. It should be pointed out, however, that the addition of blast furnace slag to concrete, in Brazil, has not been normalised yet.

2.5 Other alternatives for recycling blast furnace slag

Most gross and granulated blast furnace slags can be employed as aggregate for producing mortars and concrete. In Sao Paulo, for example, the price of aggregates (around US$10/ton) is higher than the commercialization price of basic slags (US$6/ton). In Minas Gerais , the VALEMIX Company operates a plant for producing blocks of slag mixed with clay and cement.

SILVA; ALMEIDA (1986) present the results for the evaluation of the employment of ground blast furnace slag as fine aggregate, concluding that, with some granulometric adjustments, this slag can be used as fine aggregate in mortars and concretes. Nevertheless, the rugosity of slag aggregates and the absence of fine grains demand the development of specífic dosage and application technologies. It should also be considered that some cristalised blast furnace slags may contain meta-stable compounds, which makes them susceptible to presenting expansions after some time, thus the need of intensifying studies which aim at the control and solution of these problems.

Still in the construction field, countless other possible applicactions for blast furnace slags may be investigated, such as (a) paving with granulated slag activated with lime or other compounds; (b) masonry blocks produced with granulated slag, hydrated lyme and other compounds; (c) elements for paving and (d) mineral wool.

2.6 Steel slag

One of the main alternatives for recycling steel slag in Brazil has been its commercialisation as aggregate for railroad bed. Steel slag has also been used as road base and sub-base. However, its expansive nature and the lack of reliable detection methods and criteria for acceptance have resulted in different durability problems. Recentely, some municipalities have been showing concern and restricting this application due to problems concerning users' health.

The existence of few published research results concerning steel slag recycling may nevertheless be observed. Thus, the expansion of this market undergoes (a) definition of technical criterion/a and essays for the acceptance of (dimensionally stable) steel slag lots; (b) proposition for treatments so as to go round the slow hydration composites problem, (c) investigation of recycling ways internationally practised, and (d) adequating these technologies to the material characteristics and to the national market.

3 DEVELOPMENT OF NEW MARKETS FOR STEEL SLAG INDUSTRIES

3.1 Multidisciplinary co-operative projects

Each and every market development strategy for slags steel industries is naturally conditioned to the participation of steel industries and industries willing to invest in technology. The productive chain must be represented by its different segments (manufacturers, consumers, research institutions, among others).

The active participation of the future technology consumers is a condition for adequating the final product to the users needs. In the case of recycling aiming to the utilisation of slag and/or industrial waste in civil construction, both designers and constructors must be present in the team, especially at the definition/specification phase and at final product development. This procedure is justified by the need of thoroughly studying project phases: production,

installation, use and maintenance. Aspects such as labour training, special care for installation /production, performance requirements, investments in equipment, influence of technology in the organisation of the site and cash flow of the worksite, among others, must not be forgotten.

The participation of several steel industries or other industries in the market development project usually presents positive reflexes. The market scale gain with the developed solution is one of them. The dilution of costs/investments, the growth in technical support capacity, a wider understanding and control in the chemical composition variation of slags and residues, the greater facilities for financing project research, may also be raised. The main disadvantage concerns the management of project problems. This disadvantage may be partially overcome by the involvement of sectorial steel industries and other industries, institutes and associations.

The association of different research organisms in a single project can also be very interesting, as it complements specialisations and laboratory capacity as well as disseminating technical capacitation by comprehending a wider geographical area – which may be decisive for the technology transfer phase. In Brazil, the formation of research networks has been incentived by governmental research fostering organisms. There is now a collection of funds, support lines and fiscal incentives that may be used for financing research.

3.2 Characterisation of slags

The characterisation of steel slag industries and remaining industrial wastes involves chemical, physical, mechanical and environmental impact aspects. The chemical characterisation must comprehend not only the chemical composition, but also the characterisation and quantification of the different phases, humidity and volatile content, determination of chemical composites which may result in risks for workers, consumers and to the environment itself during production, manipulation, installation and final use.

The presence of contaminants (such as slab metallic agglomerates) deriving from the very production process also has to be quantified and characterised. Many times, the presence of these products requires improvements which may impair recycling. Finally, the form to be presented, such as granulometry, volume, quantity and frequency of production also has to be raised, as those influence the technical application viability.

3.3 Selection of possible applicactions

Based on the previous characterisation of steel slag industries, alternative recycling forms may be selected, optimised from a technical and economic-financial point of view, as well as in applications in which the product can aggregate value for both the consumer and the manufacturer. This phase requires the involvement of specialists who know the market to be explored (for the thorough design of the *marketing* strategy to be adopted in the technology transfer phase) and the realisation of a consistent market research. It is desirable to have a proposition for recycling alternatives in which the final product does not have to face direct competitors.

In the case of blast furnace slag recycling, the application, for example, in the slag cement production does not present direct competitors established in the market. In this specific case, an even more adequate strategy is the use of this cement *already* in the production of building components (panels or blocks, for example). In some other cases of steel slag recycling industries, this procedure may be necessary.

An example of the importance and competitive advantage of the consolidation of final products in the market is the case of granulated blast furnace slag. By the mid 1900s there were in the European - and even in the North-American market- blast furnace slag cements activated by hydrated lime, or its admixture with sodium hidroxide. These cements were considerably cheaper than ordinary cement. However, despite their lower price, because those cements did not present the expected performance in specific applications (slower evolution of mechanical resistance, prolonged curing, among others) made these cements be banned from the market as they also created technological and psychological barriers for its resurgence.

3.4 Product development

3.4.1 Scientific approach

Product development must be carried out based on scientific and technological research. Scientific knowledge allows understanding or formulating hypotheses on the cause of a certain material behaviour. These hypotheses are fundamental for experiment planning. The scientific approach also allows for an easier conclusion on whether or not to generalise the conclusions obtained. It is also a fundamental condition to estimate the new product behaviour in the long run, based on accelerated or short-term essays. For these reasons, such approach allows for greater speed and reliability in the process.

A purely technological approach is insufficient for developing new products and, in the case of steel slag recycling industries; it may lead to gross errors. Disconsidering the presence of eventual composites, which may even fail to substantially influence the technological behaviour of the material (e.g. mechanical resistance), may affect workers' and consumers' health.

Understanding the chemical reactions nature among the different components and composites formed allows for extrapolating the results obtained in laboratory accelerated essays for the natural ageing results in different micro-climates (dry areas, wet areas, among others). Besides, when the new materials incorporate dangerous elements, phenomena such as ionic diffusion, solubility in water, evaporation of volatile composites, among others, must be thoroughly considered.

3.4.2 Performance evaluation

Many times there is an attempt to evaluate the adaptation to the use of a new product by an analogy with a traditional product. This approach is inadequate because the standards developed for controlling the quality of a traditional product are elaborated considering only specific product characteristics and some fundamental performance requirements. The development of a new product will very probably present problems of other nature and will need a customised treatment. Therefore, the application of the performance evaluation methodology, where essays are developed aiming to meet users needs acquire fundamental relevance (JOHN, 1996).

In any project aiming to develop technology to be transferred to the market, the evaluation of the economic-financial viability is also paramount. This evaluation must comprehend not only the raw material costs, but also operational costs, direct and indirect financial costs, among others.

3.5 Technology transfer

This phase is fundamental for the success of the investment as a whole in the development of a new product. Difficulties and risks must not be disregarded. The technology transfer must be planned from the very beginning of the process. In case the enterprise in charge of improvement and the constructor are already incorporated to the development process, the task is easier. It must be supported on extensive technical documentation, including project, production and, assembling manual, quality control program and guidance for maintenance and use. Talks, participation in congresses, seminars and technical meetings, elaboration of demonstrative folders and videos, among others, are tools that should not be disregarded either.

It is paramount that, at a first stage, companies which have the technology exert control on the quality of the product offered to the market and on the level of information passed to workers, constructors, designers and users. It is advisable for the technology transference program to foresee a normalisation with the Technical Norms Brazilian Association (ABNT), obtention of Technical Approval (or Technical Reference) and Environmental Certification by the manufacturer.

4 FINAL CONSIDERATIONS

The possibilities of market expansion for slag recycling interests both steel industries and society in general. For the steel industries, there is a possibility for increasing profits and for demonstrating social and environmental responsibility. For society, there are possibilities for environmental and economic gains.

Also considering that the civil construction industry consumes large amounts of raw materials and that it is spread in every region in the country, the adoption of policies for involving constructors in co-operative recycling projects of steel slag industries is particularly interesting. Nevertheless, these gains will only be possible if manufacturers adopt an adequate strategy in the research and development activities for new materials and components, which starts with a judicious selection of technically viable alternatives, also in tune with the peculiar characteristics of the market. The incentive for research and development existing in the country at present, when well used, may serve to stimulate this enterprise. To create alternative markets, it is also desirable that these projects are developed through a co-operative effort from the different steel industries and/or from industries, universities and potential technology users.

Finally, after developing technologies, the process normalisation at the Brazilian Technical Norms Association (ABNT) must be started, and it is advisable for the manufacturer to obtain the Technical Approval (or Technical Reference) and Environmental Certification.

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Environmental assessment of buildings: towards an appropriate approach to the Brazilian environmental agenda

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1. INTRODUCTION

In 1999, the International Council for Research and Innovation in Building and Construction (CIB) published the *Agenda 21 on Sustainable Construction* (CIB,1999). This report details concepts, aspects and challenges that sustainable development presents to civil construction. The role played by sustainable construction was precisely positioned and the main challenges to be faced by the construction industry were pointed out. As the majority of the contributions for this publication came from developed countries, many of the aspects, challenges and solutions were *mainly or only* applicable to developed countries. This contributed to maintain the international discussion on sustainable development dominated from the developed world point of view. Nevertheless, social, cultural and economic differences in developing countries naturally define different priorities, targets and challenges that interfere in the comprehension and strategy implementation of sustainable development and sustainable construction. Work on a new CIB document specifically adressed to developing countries and economies in transition started in November 2000.

In this context, JOHN;SILVA;AGOPYAN (2001) proposed a discussion of an Agenda 21 for the Brazilian construction sector. Development and implementation of building environmental assessment methods was included as one of the main issues. Implementation strategy is based on *Programme BRAiE*, a national research network gathering researchers and government and production sector representatives aiming to ***(1)*** identify items of local environmental agenda that must be stressed in relation to generic core evaluation; and to ***(2)*** define our building reference performance that allows for establishing targets compatible to the Brazilian reality. (SILVA, 2000).

The next section is dedicated to a concise review on key aspects involved in environmental assessment of buildings, followed by a discussion on how these aspects are being considered in the development of a Brazilian methodology.

2. ENVIRONMENTAL ASSESSMENT OF BUILDINGS

There is a consensus among researchers and governmental agencies that environmental performance rating combined to certification systems is one of the most efficient methods to elevate the environmental performance level of new and existing building stock. (NRC/CANMET, 1998). Apart from motivating for performance improvement, the development of a suitable assessment method also allows for performance specification of new buildings and for identifying realistic opportunities for improvement of the existing stock, with several positive practical results in the medium and in the long run.

The available building environmental assessment methods are naturally different but built over a common assessment core that, in short, comprehends at least 5 impact categories: *natural resource consumption*; *pollution and emissions* generation; *indoor environment quality*; *environmental commitment* of agents involved and *quality of* operation and monitoring (process); and *insertion context*.

Most assessment methods are based on a *benchmark approach*, which means that environmental credits are assigned according to the result of the comparison between the performance of the building under evaluation and a previouly established performance reference (benchmark). This reference performance could be, for example, minimum acceptable performance levels, common market practices or performance targets.

After evaluating the impact categories, some assessment methods apply ponderation to indicate relative importance among categories to reach one series of indicators (one per category), as in GBC case, or a global performance index, as does BREEAM. But not all assessment schemes apply ponderation, mainly due to the lack of a consensual basis that allow for objective judgement on the relative importance of impacts.

In the case of *LEED ™*, for example, all credits have the same weight, even though there is a clear concentration of credits in certain categories. Performance certification is granted based on the total number of credits obtained, and it is not mandatory to reach a minimum number of credits in each category (USGBC, 2000). On the other hand, in the case of BREEAM, the quantity of items in a certain category is not an indicator of its importance, but of the evaluation depth or detailing level. The credits obtained in each category are weighted to get the *environmental performance index (EPI*), a single indicator that provides the performance classification. In this case, the weighting criteria was developed in a previous work carried on at BRE (DICKIE;HOWARD, 2000). GBTool also allows for the application of different weighting factors for each category (and for items inside them) and suggests a default-weighting system. This ponderation can be redefined by the assessment teams to provide more realistic results, but the GBC Project still works on the development of a scientific weighting procedure.

One of the most effervescent discussions in the field of environmental assessment of buildings is related to the nature of the evaluation criteria (device-oriented x performance-oriented criteria). Some assessment methods are clearly feature-based and provide environmental credits when certain devices are present. On the one hand, the checklist-structure is "market-friendly" and can be easily incorporated as a design tool, but the main

problem with this kind of structure is that the completion of the list does not necessarily guarantee the best global performance. This approach can favour the qualification of buildings simply because they use certain equipment, instead of focusing on the *whole-building environmental performance,* and it has come under severe criticism during the development of new evaluation systems. At the current state of methodology development, however, the fundamental differences in the essence of evaluated items still result in hibrid methods, which try to combine a maximum of performance-based criteria with an anavoidable number of feature-based items. The assessment implementation strategy of building environmental assessments in Brazil will start on this hibrid-like basis.

3. COMMENTS ON A (DRAFT) STRUCTURE OF AN ASSESSMENT METHOD SUITABLE TO THE BRAZILIAN ENVIRONMENTAL AGENDA

The first main agreement about the desired approach for building environmental assessment in Brazil was that the method should be as much LCA-based as possible. Although this could be seen as too labour-intensive for a starting point, the idea behind it is to promote the collection of environmental data of building materials and products and use these results in whole-building assessments.

The structure based on a series of pre-requisites complemented by environmental credits, could be positively incorporated in the Brazilian case. A *"pre-requisite + credits + bonus"* structure (Table 1) is particularly attractive because it allows for continuous upgrading of the system by converting *bonus into regular credits* and *credits into pre-requisites*.

Table 1 is not complete but provides a general notion of some items that must be part of a method suitable to be used in Brasil. The immediate "translation" of international assessment methods to the Brazilian context is not feasible. Certain aspects would loose validity and, on the other hand, items not always considered in international methods should also be assessed. Just to give some examples:

1. All methods give a marked importance to CO_2 emission *during building use (GBC also considers embodied CO_2)*. This is clearly a concern of cold-climate countries (heavily heating demanding) and/or with energy matrixes strongly based on fossil fuel use. In the Brazilian case, the control of CO_2 during operation of buildings is not that valid, since ***(1)*** space heating systems are not normally used; only a small (although tending to increase) percentage of water heating is fossil fuel-based (gas) and use of inefficient electric showers is dominant; and ***(2)*** the necessity for space cooling is more frequent than for heating and is provided by electricity that comes mainly from hydro power sources. CO_2 emission related to materials production may be preponderant in many cases, and more efficient would probably be ***(a)*** to implement control measures at this stage, by e.g. implementing CO_2-emission certification to materials and processes and controling the total embodied CO_2 during materials specification (once this data is previously collected); and ***(b)*** to provide a separate control item for electricity use, as well as a *whole-building performance indicator* of energy efficiency.

2. Provide *incentive-oriented measures* to improve *e.g.* energy efficiency, that can be *device-oriented* (and, when possible, design-oriented) in the beginning, providing opportunities for (users and designers) education purposes and for shifts in the specification quality (by granting credits for the use of more energy efficient devices, instead of electric showers, for ex.). Once these measures become common-practice, the system can gradually move towards *performance-oriented* criteria (e.g. overall electricity consumption control).

3. A few items included in certain assessment methods are sometimes too detailed for Brazilian standards. LEED™, for example, takes precautions to control night light pollution. In Brazil we can not go for this sophistication level yet. Due to the absence of performance reference and environmental data, we must start from a lower ambition level, although broad enough in scope to cover all main environmental issues and include some social issues somewhat connected to the production of buildings. Items that express a high environmental commitment level like the example above could be inserted as *bonus points*. In this way, the adoption of certain measures by exceptional buildings level is encouraged, without harming others not as developed. Revisions made on a regular basis may convert bonus points into normal requirements and guarantee the necessary update of performance targets and requirement level. Finally, workforce training and alphabetization encouragement should be ideally inserted as pre-requisites, but fidelity to real context imposes their initial inclusion as *bonus credits*.

4. In such a short-term culture as found in the Brazilian construction sector, in which responsibility is seen as ending at the moment of design or building conclusion, the presentation of a *building maintenance plan* and a *well-detailed user manual* should be included in the assessment method; if this would happen at pre-requisite, credit or bonus level is a matter of further feasibility judgement according to real conditions.

3.1 Difficulties in establishing benchmarks

Whenever possible, most assessment methods relate the evaluated items to regulations at national, regional or local level. LEED™ is a clear example, with all the mentions made to several recognized standardization bodies. In the cases when there are no available standards, requirements are set according to aimed targets.

The main difficulties found as to the establishment of Brazilian benchmarks are:

(a) Lack of energy code or national standards on whole-building performance. A draft standard on bioclimatic design of buildings is currently under study, but the whole approval process can take a long time. It is difficult to establish energy performance references throughout the regions of Brazil without a complete treated climatic data set covering at least 10 years, suitable for more accurate interpretation of computer simulation results. State University of Campinas (UNICAMP), State University of São Paulo (USP) and Technology Research Institute (IPT) are now working on the production of a TMY2 data set for Campinas and São Paulo, as starting points. Simulation procedure will be able to shift from *typical design day method* to *typical metheorological year method*. IPT will then finalize the energy performance standard proposal.

(b) Outdated existing standards: utilization of rainwater or re-use of graywater, for example, are neither contemplated by current standardization. The Brazilian standards related to energy use refer only to the design of lighting and air conditioning systems. Such standards are both outdated and encourage oversizing.

(c) Lack of environmental profiles for buildings, materials and products. No Brazilian LCA databases are currently available. The author will carry on LCA studies on main building materials and compare results with available international databases.

Table 1 - Draft structure of an assessment method suitable to the Brazilian context.

Requirement level	Description
Pre-requisites	▪ ***Materials selection*** ▪ Ban of harmful final products (e.g. asbestos and lead) and processes in the design evaluated ▪ Planned ban of harmful products at company level (inclusion in the environmental policy) ▪ ***Resource efficiency*** ▪ Basic efficiency in energy and water use (consumption below a maximum level, normalized by area and occupation). ▪ Use of material-eficient solutions - limit C&D waste to ***n%*** of service. ▪ ***Process & management*** ▪ User manual - detailed maintenance and use ▪ Hygiene and worksite safety - worksite plan and use of safety equipment
Environmental credits	▪ ***sustainable sites/insertion context - for special projects only**** ▪ ***resource use efficiency*** ▪ *Water* ▪ Use of water-saving devices ▪ *Energy* ▪ Use of bioclimatic solutions ▪ Use of (and/or easy connection to) energy-saving devices and technologies (solar boilers, PV etc) ▪ Use of labelled appliances ▪ *Materials (including recycling and reuse)* ▪ Use of local and managed natural materials whenever possible ▪ Use of material-efficient solutions (design and management) - limit C&D waste to ***N%*** of service. ▪ Use of ***R%*** (in mass) of materials with recycled content ▪ *Emissions/environmental loads* ▪ ***IEQ**** *(at first, only basic requirements, i.e. materials selection, design and maintenance of systems)* ▪ ***Basic design quality*** ▪ Flexibility/adaptability (=functional longevity) ▪ Design for durability and maintenance ▪ ***Process & management*** ▪ *C&D waste separation facility at worksite* ▪ *Maintenance plan* ▪ ***Social issues connected to building production*** ▪ alphabetization facilities on the worksite ▪ workforce technical training and updating
Bonus credits	▪ use of innovative technologies (e.g. rainwater collection and treatment; wastewater re-use etc) ▪ demonstration of use of simulation programs to predict energy performance and optimize design ▪ participation in sectorial environmental R&D incentive policies
Extra environmental commitment level	▪ IEQ - equipment for CO_2 monitoring, etc

3.2 Establishing a weighting procedure

This is another controversial theme in environmental assessment since by now there is no consensually accepted method for relatively comparing different environmental impacts. A relatively simple procedure is to consult an expert panel which - from its components' background - suggests ponderation factors for the different categories. This was, in a few words, the process carried on by BRE in the UK to provide the information that allowed the

generation of a single environmental performance indicator. GBTool version 1.59 has introduced a voting sheet where up to 6 voters define the relative importance of impact categories according to the evaluation context. This version also suggests the use of this same method to derive a single performance indicator, in a similar way done in BREEAM. This kind of impasse was also faced in the 70's as to the final judgement and communication of funcional performance evaluation. This is a legitimate attempt, since it clearly facilitates the choice for one option or other, but one same number can describe very different patterns of assessed results.

To define an appropriate weighting procedure, the Brazilian GBC team had opted for consulting a large sample of neutral voters in different spheres of the construction macrocomplex. The weighting rationale will be considered to derive the final ponderation factors to be applied by GBC and other future assessment methods. Though there is not a consensus yet, the major trend is to allow for weighting among items inside categories *but not* for aggregation of categories results to reach a single performance indicator.

4. FINAL CONSIDERATIONS

Development and implementation of building environmental assessment methods is one of the main issues of the Agenda 21 for Brazilian *construbusiness*. Implementation strategy is based on *Programme BRAiE*, a national research network that will identify priorities of local environmental agenda and define Brazilian benchmarks. The works started in the State of São Paulo and will be gradually extended to other parts of the country. The main difficulties found to develop an assessment method suitable to Brazilian conditions are related to the general lack of environmental data and standardization to support establishing national benchmarks. The State Association of Constructors has now agreed on a partnership to initiate the assessments that will define a local benchmark based on typical design and construction practices and soon it will be possible to go for higher ambition levels.

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The Beauty and the Beast: The contested role of sustainable energy as a basis of architectonic design

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ENERGY EFFICIENCY MEASURES IN NORWAY

The building process is not made a particular issue in the Norwegian energy efficiency measures. This in spite of the fact that this is an arena where important energy decisions are made, as to what energy standard to choose, what energy systems to use etc. The architect profession is a particularly important actor, in this respect, due to their role as maintainers of totality and aesthetics, as well as their role as co-ordinators of the building project. Thus, to be able to produce more sustainable and energy efficient buildings in the future, it is important to understand how these issues are handled by architects.

Norwegian energy policy has particularly been based on controlling the energy consumption by using *relative prices*, supporting and funding development of *alternative energy technologies* and funding *information campaigns* addressing households. The policy goal is that energy should be used in an economically optimal way[1]. The policy is framed in quite general terms, and it is supposed to reach a number of different actors. As noted above, the official energy efficiency policy includes few strategies for affecting the actors on the middle or the meso-level, that is, the professions and institutions in the building sector that give advice and have a say in decisions about how to design and operate buildings. Thus, few if any of the measurers are directed directly towards architects. However, many of the measures are based on information and knowledge passing through the realm of architects and the other professions in the building design process in order to reach the different users and finally be integrated in the design of a building. In consequence, it is natural to expect that *communication* must be an important part of the process.

As the policy measures are quite weak and have a wide scope one can only hope for a random merging of policy and the interests and values of the architect profession. The architect profession is generally portrayed as an inquisitive and progressive group in society, and it is therefore widely expected that they will be committed to sustainability and green values. However, this is only a supposition that needs further grounding. The paper addresses how the architect profession handles energy efficiency and sustainability in relation to architectonic design.

THEORY: TRANSLATION AND BOUNDARY OBJECTS

One particular approach within technology studies that seems particularly fruitful for the study of architects' handling of energy efficiency policy, is *the translation approach*. The approach describes the process where a new artefact is invented and the inventor need to build a network

[1] Herein, the Norwegian invention of the expression of "energy economising". In this paper I will use the more common expression of "energy efficiency" for these kinds of measures.

of actors to support the invention. Building the network consist of developing different scenarios and "enrolling" the actors. When a scenario is developed, the scenario is *translated* to appeal to what is believed to be the relevant actors' needs and wishes. Thus, translation means "the interpretation given by the fact-builders of their interests and that of the people they enrol" (Latour 1987:108). In this way the meaning of a particular technology or piece of knowledge may be changed in order to adapt to different wishes. Accordingly, translation is a rhetorical method that is used to make it look like interests coincide. The translation approach also focuses on how persons or firms translate technological opportunities and economic, political and cultural conditions into socio-technical visions and strategies (Hubak 1998). Different strategies, like persuasion, seduction and motivation are being used to enrol central actors.

To transform energy efficiency from only being an assertion into being a fact, is done most easily by finding persons that are willing to believe the assertion, invest in it, or buy it. Presenting the energy efficiency argument in such a way that it will meet the interest of others may do this. Hubak's study (1998) indicates that energy efficiency to a large extent is translated by the HVAC and consultant engineers, who again translates energy efficiency to make it attractive for building owners and other professions working with the building construction (Hubak 1998: 252). However, as this paper will demonstrate, the translation process seems to be more complicated regarding the architect profession.

The social studies of science literature has identified a set of objects that make the translation process go easier, namely "boundary objects" (Jasanoff 1995; Star and Griesemer 1989). The concept of boundary objects is useful for analysing how collective action is managed across social worlds to achieve enough agreement at various times to get work done and produce relatively (and temporarily) stable facts (Fujimura 1992). A boundary object is an analytic concept of scientific objects that both inhabit several communities of practice and satisfy the informational requirements of each of them. Boundary objects are thus "both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across boundaries." They are weakly structured in common use and become strongly structured in individual-site use. These objects may be abstract or concrete. "Such objects have different meanings in different social worlds but their structure is common enough to more than one world to make them recognisable, a means of translation" (Star and Griesemer 1989: 393). As the focal point of the boundary work is collective work across different communities of practise with different viewpoints and agendas, the theory should also be fruitful for studying the realisation of energy efficiency measures in the building sector.

METHODOLOGY AND DATA MATERIAL

Two Norwegian architect journals have been used as data material, namely "Byggekunst" [Built Art] and "Arkitektnytt" [Architect News]. These are the two most important Norwegian architect journals. Built Art has been claimed to be the most important source of reference for Norwegian architects (Helland 1988). Architect News is the architects' main forum for news and debate circulated to all members of The National Association of Norwegian Architects (NAL). Thus, it is read by a high proportion of Norwegian architects and can thereby be seen as a central forum in which one might explore the status of energy efficiency and environmental concerns in the profession. The analysis covers the period from 1970 to 2000. In this period every third volume have been analysed, as well as all volumes between 1997-1999. All articles from the sampled volumes which comment upon the actual research question (i.e. which discuss energy efficiency, ecology, environmentalism, sustainable development etc.) are sampled and analysed.

Given the explorative nature of the study, it is very helpful to combine the analysis of relevant documents and texts with interviews. The interviews were conducted during winter 1999 and spring 2001. Altogether, 37 persons were interviewed. Of these, 22 interviews were with architects working as practising architects in 11 different architect firms in Oslo and Trondheim representing a broad sample of Norwegian architect firms, as university professors, in research and as profiled spokespersons in central organisations related to design and architecture. 15 of the interviews were with other actors in the building trade (consultant engineers, building owners, contractors, represents of the EcoBuild Programme) that are important in relation to a building's energy standard. Most interviewees are made anonymous and given new names in the paper.

TRANSLATING ENERGY EFFICIENCY INTO SOMETHING "BEAUTIFUL"

A review of Built Art and Architect News between 1970 and 2000 suggests that there does not exist a widespread interest of energy and environmentally sound design among architects in Norway (Ryghaug 2000). Few contributions in the journals focus on energy efficiency and sustainability. These topics are diminutively introduced and are slightly highlighted in reviews and presentations of buildings. However, Architect News nuances this picture slightly, as it to some extent render a debate concerning energy, ecology and environmental issues that has been taken place lately.

Nonetheless, the main finding is that most architects are not concerned with energy efficiency. Interviews with persons working within the EcoBuild programme (a readjustment program for the building and property trade to get more environmentally effective buildings) support this finding. One employee admits that it has been particularly difficult to reach the realm of architects and that one only reaches those who are already interested: "We have worked on getting the trade together and the trade has congregated quite strongly. But it is extremely difficult to find measures that architects support and which they include themselves in. The architects feel most comfortable standing alone. (...) We have coaxed, wormed and threatened, and we have tried to make the architect profession understand that they have to do something, but they obviously haven't understood it well enough" ("Hansen" p.1).

The lack of interest in energy efficiency among architects indicates that the authorities have failed to translate energy efficiency into something that engages the architects. This is probably due to the fact that the architect profession is not figured out as a clear target group of the energy efficiency message, and consequently that the message to a very little extent has been accommodated or tailor-made to suits their interests. Energy efficiency have politically been promoted in terms of an economic and engineering-technological argumentation that is based on the assumption that the market itself will chose energy efficiency simply because it portrayed as economical and that good technology spreads by its own. Energy efficiency is presented as politically correct and something that it is impossible to argue against. This way of reasoning does not seem to induce the architects and architects have accordingly put little effort into energy decisions although they have a strong negotiating position. Consequently, the decisions in the building design process are not affected by technological development and price mechanisms in the way that the official energy efficiency policy assumes.

To make the energy efficiency message reach the architect profession energy efficiency has to be presented in a way that makes it possible for architects to translate the message in line with their own interests and goals. The analysis indicates that it is the aesthetic expression of a building that engages most architects. Thus, the analysis of the architect journals suggests that aesthetics may

be a point of rupture or a boundary object in relation to understanding the way architects handle energy efficiency. Is aesthetics what constitutes the architect profession, then?

NABU (Norwegian Architects for a sustainable development) is an organisation that have tried to bridge the gap between the policy goals and the architects, by trying to get the architects more interested in sustainable architecture. According to NABU the old prejudices against ecological buildings are not valid anymore, as they emphasise that ecology and sustainability is not about form, but contents: "One tend to think about one style after the other, through history, now there is modernism and we wonder what will be the next style because we think linearly. I think ecology belongs to another paradigm and that we therefore should ask a different question, where the point is to say that this is not primarily about form – it is about contents. This is important. I think that architects should try to be a little less preoccupied with form". This observation supports the assumption that the aesthetics, and modernism in particular, is the ruling constituent for the architect profession of today. This makes the strategy of encouraging architects to be less preoccupied with form an unpromising one, as this seems to be a trickier task than trying to translate ecological and energy efficient architecture into remarkable architecture.

In order to be able to design energy efficient buildings energy efficiency must be communicated from the political community to the community of architects. The use of boundary objects would be one way to link the two societies and create a way of communicating between them. The most obvious candidate to being a boundary object between these two separate worlds, is the concept of energy efficiency itself. Establishing the energy efficiency concept as a boundary object may serve as a meeting ground between actors on either side of the architect/policy maker boundary. This as a result of boundary objects usually playing "a critical role allowing different communities to work together around them and yet maintain disparate identities" (Guston 1999, p 89). Thus, the question here is to what degree does the concept of energy efficiency function as a boundary object that facilitates the translation from the realm of policy to the realm of architecture.

A rewarding explanation for the difficulty in translating energy efficiency into something inspiring is the lack of boundary objects that could have facilitated the translation. The concept of energy efficiency is a politically constructed artefact that has yet to enter the community of architects. It does not seem to function as a boundary object between energy efficiency policy and architecture. The concept is almost absent in the overall architect discourse and something most architects are reluctant to talk about as they have little interest in the topic. When asked about the concept of energy efficiency it is mostly brushed aside as something that has to do with amendments of old houses, increasing the use of insulation, installing energy saving light bulbs and water saving equipment. Energy efficiency is not perceived as a common goal and conventional understanding among architects.

There exist two main poles within Norwegian sustainable and energy efficient architecture; the first is a low technological movement dating back to the 60s often associated with the use of wooden materials, turf roofs and a style similar to traditional cabins. The other movement is the high-tech energy buildings that often use double glass facades or complicated ventilation systems in the building and where the technology traditionally is thought to be more important than the shape of the building. The interview analysis indicates that neither high-tech energy efficiency nor low-tech ecology produce architecture that most architects find appealing. The eco- and energy-friendly architects are not the trend-setters of the profession. On the other side, those who are trend-setters do not design particularly energy efficient and ecological buildings. It is

therefore appropriate to conclude that the energy efficiency policy to a large degree has failed to be translated into something that most architects find attractive or even persuasive.

One reason for this is probably that traditional low-tech ecological architecture has an aesthetic expression that most architects find objectionable, as it goes against their preferred aesthetic expressions of modernism. One example is roof design. The acute angles and pointed roof design of these houses are two of the features that make this architecture unfashionable, as flat or arched roofs is the trend in architect circles. One of the leading persons representing sustainable architecture admits that ecological architecture in some ways may be in conflict with modernism and open form, as ecological architects often strive to divide the building into zones (to prevent that the whole house has to hold 22° C).

Architects also seem to reject the potential boundary objects that the engineers offer in form of new technologies, as they are very sceptical towards using *technology* as expressions of form. Whenever a new topic or a new set of problems is introduced they will typically focus on finding a formal architectonic answer to the problem. Finding a new architectonic answer to a problem, like for example environmental problems, implies looking for something that may symbolise the environmental aspects. Creating such symbols may create a greater consciousness of the green aspects in buildings, but it could also become so eccentric that it has no transmission value. According to an architect working within research, this is an all right way to create interesting single objects, but the solution should not be so strange and special that it cannot be employed in most buildings. This is however, what seemed to have happened to many ecological and energy efficient buildings. It has become a sort of "interesting but queer research" (Moe p.9).

A recurring example of how energy efficient technology and ecological techniques often is used to symbolise environmental concern, mentioned by many of the informants, is the Swedish Eco-schools. These schools are often used as examples of how ugly a building can get when one let the ventilation system become the governing design principle. The schools, around twenty in number, look almost exactly the same; they have about fifty chimneys on the roof and look like "extremely long barns". Consequently, the architects are accused "of not taking the challenge of forming them properly" (Winther and Davidsen p. 2, Sundahl p. 14). One school uses pellets for heating, which is considered all right. However, the architects remark that "as a symbol of how clever they are they have built a pellets tower!" , which according to Winther and Davidsen is a "good example of technology being used as design criteria, and as trademark", which they are very critical towards (p.5). Consequently, dislike of ecological and environmental architecture may be explained by the extensive use of symbols, like solar panels on the roof, discharge water running trough reed etc. and the extreme expressions of form that many of these buildings have according to the architects.

CONCLUSION

The paper demonstrates the problems of understanding technological innovation processes (as for example implementation of energy efficient technology) without regard for the meso-level characteristics like the features of central and professions involved. Macro-political means for implementation of measures may prove to be very ineffective if the meso-level is overlooked. The article suggests that this is likely to be the case with the Norwegian energy efficiency policy.

Most architects seem to consider neither the high-tech nor the low-tech traditions within sustainable architecture very relevant or influential. The reason for this is probably related to the architects' definition of good architecture being strongly related to form and aesthetic criteria, and the inability of government policies to translate energy efficiency into something that

converge with these criteria. The government has not reached the architects with its energy efficiency policy and the policy has not been translated into important criteria of good architecture. Further, there do not seem to exist any boundary objects that could facilitate such a translation, and most architects seem to dismiss the potential boundary objects that are presented to them in form of new technologies, as they are sceptical towards using technology as design criteria.

To make architects more interested in energy efficiency, it is not sufficient to present economic and technological arguments. The arguments should be presented in a way that makes it possible to translate energy efficiency into something compatible with the goal and interests of architects. One way of doing this is by giving the architect the opportunity to translate energy efficiency into something that is in line with their interest of aesthetics. To reject the aesthetic as a boundary object is probably not a very fruitful strategy. As form is exactly what most architects are interested in. A more viable strategy would be to show how energy efficiency could be translated into something that converges with the aesthetic values of most architects. Thus, by looking for the "beauty" in the "beast".

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How to Obtain a Sustainable Environment Using Performance-based Regulations – and Appraisals

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1. INTRODUCTION

Now that there is ever increasing evidence that we are warming our planet with CO_2 production, we need to take stock of how we are treating our protective atmosphere, before it turns against us by locking in uncontrolled global warming. In the last century, we somewhat recklessly kept using resources, especially through the continual increase in the use of energy. The environmental impact of this usage has become a major concern, and if we don't change our energy usage now, the costs for future generations could be devastating. If we hope to obtain a sustainable habitat on our planet, we need to reduce our energy consumption in the developed world. In the developed countries the energy usage per head of population can be up to an order of magnitude above that of some underdeveloped countries.

On several occasions throughout geological time, the earth has been without polar icecaps and, with uncontrolled global warming, we have the potential to melt them again, with the possibility of raising the sea level 70 m (Cooper 1999). Such a rise would not only flood over 70% of the world's major cities, but, more importantly, the river valleys where most of our food production occurs. So apart from having a major shortage of housing, food supply would be critical; a disaster similar to that which brought an end to the dinosaurs. The difference between the dinosaurs and us is that the dinosaurs had no control over their climatic change, while we can do something about our current global warming.

One of the major eaters of our energy usage is buildings, not only in their daily operation, but also in their construction and even in their demolition at the end of their service life. In the past, the main concern in building construction has been the long-term durability of our buildings, but in fact many have a service life of less than 50 years. We will need to rethink the way we build in the future. By using performance-based regulations we have the ability to take up the use of new and innovative building systems and materials that will not only use less resources, but in some instances may increase the use of recycling materials and existing building stock. However, due to the conservative nature of our industry, to give the consumer the necessary confidence to accept innovative solutions there will be a need for them to be independently assessed.

Firstly, lets have a look at how the performance-based regulations can assist in reducing global warming by introducing new low-energy construction.

2. PERFORMANCE-BASED CODES

The prescriptive-based regulations of the last century made it very difficult to move away from traditional forms of construction. These regulations defined the size and types of materials that could be used. New materials or methods of construction that emerged often ran into a brick wall due to the difficulty in meeting these requirements. One charter of the World

Organization of Building Officials is to house all the earth's human population in accommodation that promotes increased standards of health, especially those currently without permanent shelter. Even for basic housing, traditional construction results in a huge energy increase. Housing to accommodate these homeless will need to be tailored to match the environment rather than just following traditional construction. As an example, Singapore tends to rely on British Standards rather than codes written around building in the tropical conditions experienced in the area.

Overall energy usage will need to be assessed and building will need to suit the environment in which they are constructed rather than blindly following fashion trends. A typical example is in Australia, where there is a trend to build houses with little or no eaves overhang. This fashion is being copied from designs used in North America and Europe, where heating is a major use of energy and cooling is of little concern. In a temperate to tropical climate, as in Australia, energy consumption for summer cooling is the highest usage. Thus, shading the periphery of the building with sensible eaves overhang creates significant energy savings in cooling. A correct eaves overhang can shade the windows and external walls during summer but allow warming from winter sun. This is not rocket science but just commonsense. Solar tables for orientation and eaves overhang were produced by Spencer (1960) for Sydney, followed by tables for all Australian capital cities. It is only just recently that governments have started to think about encouraging correct orientation of domestic construction to take advantage of solar conditions.

To expand on this further, in some Australian states there is a requirement to have a certain thermal resistance value (R) for those parts of the external walls that are not windows or doorways. However, some designs used in Australia have 70% or more of external walls consisting of doors and windows. Is there sense in requiring an *R* value for 30% of the external wall if there is no thermal requirements for the glassed part of the wall or even airseal requirements on the windows or doorways? Only recently in Australia a rating has been introduced for the airtightness of windows. If an overall requirement on thermal performance of the building was in place, then the designers would have scope to meet this performance in any way that could show compliance. This would open pave the way for innovative ways of increasing the thermal efficiency, rather than compliance with a questionable prescriptive requirement.

However, one needs to be careful as to how the performance is defined. This is not as easy as one may expect. Often, a requirement can be phrased in such a way that it looks very performance-orientated, but still can be restrictive on materials or building systems. On the other hand, the performance may be written in such a way that there is no definitive level against which to measure. Let's take an example from the current Building Code of Australia (BCA 1996). For sarking material (an Australian term often known as building wrap in other countries), there is a requirement to meet the performance clause CP2 of the BCA. This clause states:

> **CP2** A building must have elements which will, to the degree necessary, avoid the spread of fire-
> (a) to exits: and
> (b) to sole-occupancy units and public corridors: and
> (c) between buildings: and
> (d) in a building.

Sarking materials need to meet Clause CP2(d), but there is no definitive measure of what is needed to meet this requirement. On turning to the specification section in part C1.10, clause 2 states:

> Except where superseded by Clause 3 or 4 any material or component used in a Class 2, 3, 5, 6, 7, 8 or 9 building must-
> (a) in the case of a *sarking-type material, have a Flammability Index* not more than 5 (when tested in accordance with Australian Standard AS 1530.2–1993 'Test for flammability'), or
> (b) in the case of other materials, have…

The specification clause 2(a), on first reading, would seem to be the method of measurement that must be reached to meet the performance clause CP2. Some materials now used cannot be meaningfully tested to the clause. The test method used to measure the flammability index for sarking given in AS 1530.2–1993 'Method for fire testing of building materials, components and structures – test for flammability of materials', holds a strip of the material vertically over a measuring scale. A small standard flame is placed in contact with the bottom corner of the specimen to ignite it, and the height to which the material burns is recorded as the flammability index. This is fine for cellulose-based materials that were the only type when the test was derived, but now there are products that are plastics-based, usually from polyethylene. These plastics-based materials shrink away from the flame without igniting, so the test, or any result from it, is not really meaningful. Thus, it is not possible to show compliance in a measurable way to the BCA requirement in clause CP2.Several manufacturers of these plastics-based building wraps have come to CSIRO Appraisals for an assessment of their material against the BCA. (CSIRO Appraisals is similar in function to the National Evaluation Service, in the USA, or the BBA in the UK.) The way that CSIRO Appraisals has assessed these materials is to have them tested to AS 1530.3–1999 'Method for fire testing of building materials, components and structures – simultaneous determination of ignitability, flame propagation, heat release and smoke release'. Undertaking testing to this method provides a measure of ignitability, flame spread and smoke developed. Results can then be used by fire testing experts to determine compliance to clause CP2. While CSIRO Appraisals has no problem with such an evaluation, there are some building officials who have difficulty in that they see the only way to comply with CP2 is to meet the deemed-to-comply specification clause 2(a). It must be emphasised that it is the performance clause that must be complied with, and that the deemed-to-comply specification is one way of meeting the performance clause, but not the only way.

Plastics-based building papers are further disadvantaged in Australia by the loading classification they receive by relating their loading capacity to tensile strength. We all know that the failure mechanism for these papers from wind loading is tear around their fixing points. While in one medium there is a relationship between tear strength and tensile strength, this direct relationship does not hold when it is used for different materials. Thus, the plastics-based material ends up classified as 'extra light duty' when, in fact, it can withstand more load without tearing than a paper-based product which is rated two grades higher as 'medium'. This shows the need for an expert with a sound knowledge of materials to obtain a correct interpretation of results. While in this example a blind interpretation gives a conservative result, it could just as easily give a non-conservative result in some other instances where the testing used is not directly related to the failure mechanism.

With any performance-based code, there will always be a need for deemed-to-satisfy clauses that can be used for established building systems. It may not be possible to assess new systems and materials against these deemed-to-satisfy specifications, and they may need to be assessed directly against the performance requirements of the code. This assessment needs to be done by persons with the required expertise to make well-informed judgments about the compliance to the performance clauses. Thus, there is a need to have some system where the required expertise can be called upon to give independent assessments that the regulatory requirements are met. In most developed countries, there are technical assessment bodies that can assist in assessing if compliance with the required performance has been achieved.

Over the past six years, the various bodies that undertake technical assessments of building products and systems have been meeting together, and four years ago formed the World Federation of Technical Assessment Organizations (WFTAO), of which CSIRO Appraisals was a founding member. The main aim of WFTAO is to assist in the use of technical assessments in the acceptance of novel and new building products into industry. The members of WFTAO come under a variety of names, including agrèment, appraisal and evaluation bodies. While their names vary, the service they offer is basically the same. For the purpose of this paper, I will refer to them as technical appraisal bodies. To show what can be achieved from this understanding of each other's work within WFTAO, let me give one example. An Australian manufacturer of a housing system has gone from a 95% domestic market to an 85% export market. This has come about mainly from the close working relationship that CSIRO Appraisals has established with the International Conference of Building Officials, which is based in California.

The understandings that are being developed within WFTAO can assist in making more energy-efficient construction. Methods that have been assessed by one of the member organisations will be able to be passed onto the others. It does not really need to be stated that increasing the market size, such as given in the example of the Australian manufacturer above, greatly reduces the overheads of the development costs that are charged to each building. Costing will always be a major factor in the building industry, as buildings are the single most expensive item purchased by individuals or companies. Thus, not only does this have a direct effect on the uptake of new products and systems in the industry, but it also has a secondary effect of reluctance to take risks when making decisions on such large investments. Having fully independent assessments made on fitness for purpose by organisations belonging to WFTAO will assist in building community confidence in new developments within the industry. Thus, there are considerable gains for all from the development of WFTAO. Within the organisations that make up its membership, there are the skill levels and experience needed to ensure that correct decisions are made as we change the way we build our shelters and the effect this has on our environment.

3. TECHNICAL APPRAISAL BODIES

Firstly, we must look at the knowledge that is required of these technical appraisal bodies so building designers and consumers can use the systems appraisaled by them with confidence. It is important that these bodies have access to a wide range of expertise in testing so the test results can also be interpreted against the mandatory building codes' performance requirements. They also need to have both an understanding of the regulations and also how building officials interpret them. Thus, to undertake meaningful evaluations that will meet all the requirements of the industry, there needs to be input from practicing building officials, working together with expertise from the scientists. An often occurring problem is the need to guide the input of the scientists to keep them directed to only finding that the required

performance has been met. Science, by its very nature, wants to find the exact answer – this is what science is all about. For appraisals we only need to know that the milestone has been reached. By how far it has been reached, while of academic interest, is of little interest to the industry who only need to know compliance to the regulation has been obtained. It is interesting to note how different countries have found methods of directing the science input into the appraisal process. In the UK, for instance, the British Board of Agrèment was formed as a separate body from the Building Research Establishment, although they are on the same campus. In France, their main building research institute, CSTB, undertakes appraisals. In Australia, the transition of test results into performance requirements is undertaken by CSIRO under the project CSIRO Appraisals.

It is my personal view that it is only possible for researchers to be kept on track in appraisal work if they are managed by someone who has had a background in research at the workbench level. Having a research background, it is easy to detect when the direction of the testing is straying from 'practical' into the 'pure' research area. Not only does this direction keep the direct costs down, but, more importantly, the time to complete the appraisal to an acceptable time frame. Keeping the time frame under control has a huge influence on indirect costs, especially for the innovative type of product where cash flow is very important.

CSIRO Appraisals is somewhat unique in its structure, as not only does it use building officials and scientists in its appraisal process, but it also has practicing builders involved in its advisory committees. Having builders involved in the evaluation process has been described by Schafer (1994), When CSIRO took over the operations of ABSAC it saw the value of keeping practicing builders involved. I find this involvement most useful, as often they come up with aspects that the scientists would never consider and which play a major role in the final performance of the product within the building. Often, even early in the appraisal process, they will point out aspects that need to be addressed, particularly to do with adjoining components and trades.

An example of team effort is shown in a testing program established to evaluate water-based waterproofing compounds. There is an increasing environmental demand for these systems to restrict the emissions from the established hydrocarbon-based products. The practice in Australia is to lay waterproofing membrane under the tile bed. Thus, the membrane needs to function below a saturated tile bed. Solutions of chemicals used within the wet area can find their way onto the surface of the membrane. The builders on the advisory committee kept emphasising that a critical position where waterproofing membranes need to function is at the wall/floor junction. At this junction, the membranes need to cater for the movements that occur between the changes of substrates. Leakage at this location can result in water penetration into adjoining rooms, which means non-compliance with the BCA. The test procedure is described by Schafer (2002) where tensile test samples are immersed in solutions of sodium hypochlorite (bleach), detergent and de-ionised water. A typical example of a membrane that passed the test procedure is shown in Figure 1, and one that failed in Figure 2.

The test procedure developed by CSIRO is currently being written into an Australian Standard. This membrane example in fact shows the complete cycle of development of an assessment procedure. Initially the materials were assessed against purely the performance requirements of the code. Then, as the testing has been refined, it has reached the stage of being adopted into a standard that shortly will be called up as a deemed-to-satisfy solution.

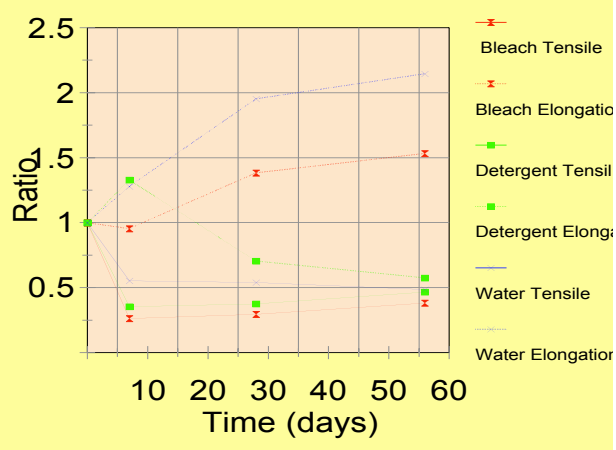

Figure 1 Tensile strength and elongation at break results for a membrane that passed.

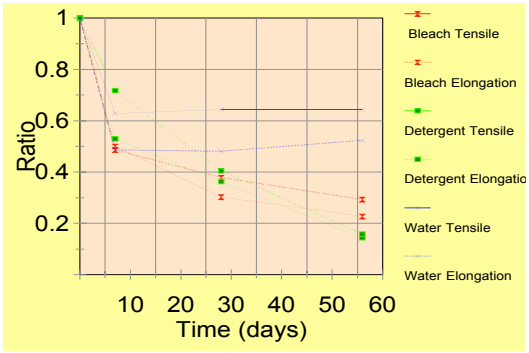

Figure 2 Tensile strength and elongation at break results for a membrane that failed.

4. CONCLUSION

There is no doubt that if we are to reduce our CO_2 emissions, then the construction industry will have to play a role as a main user of our total energy consumption (Ambrose *et al*. 2002). With the change to performance-based building codes, we have the tools to take up the challenge, to use new materials and systems and to not only construct new building, but, even more importantly, to recycle our existing stock. By using the expertise of our appraisal bodies we have access to the best advice available to make informed judgments on the use of the new materials and systems that we need to adopt if we are to obtain the required overall reduction in greenhouse gas emissions.

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Straw Bale in China

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INTRODUCTON
Four years ago I was contacted by the non-profit organization know as Adventist Development and Relief Agency (ADRA). I was asked to assist in the construction of a straw bale school in China. A few months later I went to China and helped build, what is believed to be, Chinas' first straw bale building.

On New Years day 1998 an earthquake killed 49 people and destroyed several villages in Hebei Province, China. Under the creative and resourceful direction of Scott Christianson, ADRA volunteered to lend relief assistance. It was decided between the Chinese officials and ADRA that rebuilding a school would be the best use of the available funding. ADRA then proposed to build the school with straw bales. Scott, seeing the need for affordable insulated housing in Mongolia, had introduced straw bale construction there three years earlier.

QUALIFICATIONS
Based on five years straw bale experience and twenty-five years of construction experience, I was chosen to teach the process of building with straw to the local people.

ARRIVAL
I landed in Beijing in mid August and was driven through golden fields of grain, seven hours northwest, to the city of Zhanbei. Not far away, in the village of Zhou Dongpu, was the site of the new school.

The construction crew was eagerly awaiting my arrival and began excavating for the foundation within hours of receiving the building plans from me.

PROJECT
American architect Kelly Lerner had visited the site only a month before my arrival on her way home from managing straw bale projects in Mongolia. Kelly met with potential builders and assessed the local building materials and techniques and immediately began a plan for the new school. Assisted by engineer David Mar, Kelly designed the school to fit the local vernacular, be super energy efficient and to be very resistant to seismic activity. It was my job to supervise the incorporation of straw bales and see that the seismic design criteria was implemented.

The crew consisted of approximately twenty local farmers/crafts people. They worked seven days a week and alternated days off so they could tend to their farms when not building.

The original plan was for me to supervise the construction of a hand operated bale press and oversee the arduous task of making enough bales by hand to build the school. Although bales can be made this way, the quality for construction purposes is relatively poor. As good

fortune would have it, someone in the village knew the whereabouts of a contraption for making bales. In a village an hours drive from our site we found a man who owned a very old but sturdy stationary baling machine. It was able to make the neat, tightly compressed bundles we were unsuccessfully attempting to assemble with our crude wooden bale press. The man was contracted to bring his crew and the baler to the site and manufacture 1100 of the high quality bales over three days time. The local farmers, using mule and horses, brought wagon loads of straw by the score. Each load was carefully weighed and paid for by officials in charge of the project.

The building consisted of four rooms. There were two classrooms, an office and a boiler room. The design was a simple 200 square meter rectangle using steel T posts to bear the roof load. Steel trusses were fabricated locally and hoisted into place by hand (a formidable and scary task). Composite roofing panels were installed over wooden purloins. Kelly chose the composite panels over the traditional clay tile roof for relative lightness in the event of another disastrous earthquake. The ceiling insulation consisted of straw bales designed to drop in between the steel trusses and plastered top and bottom. Bamboo was used as purloins placed perpendicular to the trusses to keep the bales aloft. Bamboo was also used to straighten and stabilize the straw bale walls. A plaster lath made of reed mat was applied to the ceiling before plastering.

TRAINING

Although I brought several books on straw bale construction with me, only the illustrations were of any value. The language barrier was significant but not impossibly so. Since everyone on the crew had some building experience, teaching the methods of straw bale construction was very easy. Once the critical details were worked out on paper the construction supervisor instructed the crew on what to do. Through my translators, I kept in close communication with everyone involved and was on the site most of the time.

WHY STRAW?

The environmental and financial benefits of straw bale building are well documented. It has also been proven that straw bale construction is very well suited for seismic design.

Although earthquakes are common in this area, the design of the buildings do not reflect concern about the fact. David Mar, who lives in earthquake prone San Francisco, has found that straw bales are extremely resistant to seismic movement especially when combined with steel wire. The entire structure was covered with wire lath, inside and out, effectively forming two interlocking cages. It was then coated with cement stucco. The result was a rigid shell, which will fail in a severe earthquake. The straw and steel act as shock absorbers and resist failure much better than rigid materials such as bricks. A quake measuring 5.8 was recorded in 2000. The school suffered not so much as a crack in the stucco.

During my stay in Hebei Province the hillsides were alive with men and women working in the fields. They hand cut wheat, oats and flax and stacked the sheaves upright to be collected later and threshed. Threshing is the process of removing the grain from the stalk. The stalk is straw, which is normally used for animal bedding or burned. The burning contributes much smoke locally and CO2 to the atmosphere globally. Using straw for building was not new to the people of this area as they have used it for fiber in mud bricks for centuries. The lack of mechanical balers there could explain why straw bale construction has not been used.

Cereal grains, from which straw comes, grow in virtually every arable region of the earth. Straw is a byproduct, which has very good insulation properties. This type of construction is easily taught and learned. and provides a very forgiving medium for the novice and do-it-yourself builder.

Workshops are often conducted wherein twenty to seventy people gather and raise the walls in a single day or two. This was not the case at the Zhou Dongpu School, but it can be an extremely efficient way of building. It also is a very effective way of including the whole community in the building process.

The idea of using straw to build the community school was received with mixed reviews. The most vocal skeptic was the construction supervisor Mr. Li. His first concern was that the bales would compress under the load of their own weight. I had the same concern when I was being introduced to straw bale construction ten years ago. It was not until the 10' 6" (9 bales tall) walls had been erected that he was assured that settling (compression) would not be a problem. He also had concern for the functional value of straw within the community. Straw is used as kindling to start the coal fires for cooking and home heating. It is not entirely a waste product as it is regarded in many areas.

Soft coal is the soul source of home heating in this region. The air pollution was astounding on many days merely from cook stoves burning coal. This was late summer/early fall well before the heating season.

CULTURAL

I was assigned two translators who made communication not only possible but enjoyable. Day to day functional communication was always entertaining. Technical information often took hours to discuss, and conceptual or ideological conversation was all but impossible.

Because I was considered a "foreign expert", it was prohibited for me to do actual hands on work. Being a craftsman, this was difficult, but it allowed me to focus on the overall progress and documentation of the process.

This part of China had not been open to foreigners in nearly fifty years. I was indeed a novelty everywhere I went. Saying "neihou" (hell-o) was incredibly powerful. A face of concern, confusion, or fright was almost invariably softened to one of delight and curiosity upon hearing the familiar greeting. Many people at that point assumed I could speak and understand Chinese and would begin a conversation. At that point my trusty, and always friendly, translators would get involved. Interaction with the children, who are now using the school, was a very rewarding part of my experience. Daily exchanges of "hell-o" for them, and "niehou" for me, became almost like a call and response song. This enabled us to overcome our strangeness to each other and allow us a way to communicate just being human.

Meals of "authentic Chinese" were cooked in a small house near the school. An after lunch nap was standard practice giving all the crew a refreshed approached to the second half of the day.

RESULTS

It was reassuring when in the last weeks Mr. Li, who had earlier been skeptical, began to express his ideas of optional ways to construct certain details. We drew line drawings of

other ways to accomplish architectural effects and structural details. We laughed at our ability to communicate with only pictures and occasional sighs and groans.

We don't have final statistics for the heating costs of the new school and comparison figures to like size buildings of traditional construction. It is not out of the question that fuel savings could be as high as 90%. One problem that arose, while trying to monitor actual fuel savings at a straw bale building in Mongolia, was that the inhabitants were accustomed to opening a door or window when the building got too warm. This, of course, has the effect of cooling the room down but wastes large amounts of energy in the process. It also nullifies any attempt to accurately monitor fuel needed.

Most buildings in the area have little or no ceiling insulation and the walls are made of clay bricks. It is safe to say our super insulated school vastly out performs others of its size and required considerably less energy to produce the materials.

I was very impressed with our crews' ability to do more with less. The only power tools on the entire job were a drill, table saw, cement mixer and an arc welder. The wooden door and window jambs were built with mortise and tendon joints using no mails. A flu pipe, which connected the furnace to a free-standing smoke stack, was cast on site using locally available materials. All the crew worked on almost every aspect of the project, the steel crew and electricians being the exceptions.

CONCLUSION

Adaptability of straw bales to existing building systems is virtually unlimited. In the decade that I have been involved in straw bale construction I have seen a huge international out pouring of interest and creative applications. As the information continues to spread, and systems are modified and improved upon, straw bale construction may replace systems which have long been in use but are environmentally problematic.

It must be noted that straw bale construction is more labor intensive than many other types of construction, but in areas where labor is plentiful it is often an excellent choice. China is certainly one such place.

Convincing the world this sustainable building system is indeed appropriate for nearly every region is not without its' challenges. The concept of straw houses has been cursed by the story of "The Big Bad Wolf" in western cultures. Making major changes in standard building practices anywhere takes patience and persistence. The users of the system must be able to see immediate advantages. Straw bales are attractive in this manner because straw is cheap and fuel saved in the heating season is money in the pocket.

I left China with great hope that our little school will influence how a few more buildings are built and those influence a few more etc., etc. Considering the population of China (1.2 billion) this "influencing effect" could have staggering results.

I hope, by sharing the little I know about this beautiful way of building, a great revolution of sustainable building sweeps across Asia, Europe, the Americas and the entire world.

The Green Building Initiatives

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1. INTRODUCTION

The Government of the Hong Kong Special Administrative Region (HKSARG) is committed to promoting Sustainable Buildings. This is evident in the Policy Address 2000 given by the Chief Executive, Mr. Tung Chee Hwa. He stressed the importance of innovation and technology for future economic growth and pledged continual vigilance in protecting the environment.

The Buildings Department is the arm of the HKSARG that forged the green building movement. This paper chronicles our efforts in breaking new grounds for a market driven green building industry that deliver environmentally friendly buildings.

2. GREEN BUILDING MOVEMENT

The primary responsibility of the Buildings Department is to ensure compliance with statutory standards set in the Buildings Ordinance for the private sector. We are the regulators that "provide for the planning, design and construction of buildings and associated works; to make provision for the rendering safe of dangerous buildings and land; and to make provision for matters connected therewith." The green building concept is in line with our vision: "To make the built environment safe and healthy for our community", and mission "To set and enforce safety, health and environmental standards for private buildings."

We have adopted a set of comprehensive strategies to set the Green Building Movement rolling. A host of green initiatives aimed at bringing quality living for our people in a multi-dimensional and progressive manner swung into place at the beginning of the Millennium.

3. DEDICATED TASK FORCES

One of the first tasks in the green building movement was to set up two dedicated task forces to drive the movement. In July 2000, a special unit named the Building Innovation Unit was formed within the Buildings Department to explore ways to secure sustainable development by encouraging the construction of green and innovative buildings in the private sector.

In November 2000, we invited directorate representatives from related government bureau and departments to join the Inter-departmental Working Group on Environmentally Friendly and Innovative Building (W.G.). Chaired by the Director of Buildings, to-date, members of the WG has expanded to the Architectural Services Department, Housing Department, Lands Department, Planning Department, Electrical and Mechanical Services Department and the Housing Bureau. The WG is instrumental in formulating coordinated and coherent packages of incentives that would benefit not only the private sector but also the public sector. About 50% of our population lives in flats built by the HKSARG, as such we believe this green movement should pervade both sectors of our city.

4. INCENTIVE SCHEMES

Prior to the turn of the century, we have only witnessed a gradual emergence of green buildings in Hong Kong. Albeit the building industry is ready both in mindset and technology to join the Green Building Movement, time constraints and costs implications often deter designers and developers from embracing environmentally friendly features in building developments. To kick-start this relative inertia, the WG derived packages of incentives to introduce to the building industry.

Unlike many other countries at the vanguard of sustainable design, Hong Kong faces a different set of environmental issues. Due to the hot and humid tropical climate, our demand for cooling outstrips that of heating. Besides, we have a population of 7 million who live on a total of 1092 km^2 of land, of which around 80% are country parks or not built over. This leads to a unique high density and high-rise living in the built over areas.

To control intensity of development in any given district of the city, two main control parameters came into play. Population density is controlled by the total permissible Gross Floor Area (GFA) allowed for a site and its corollary Plot Ratio (PR). Building bulk is controlled by the total Site Coverage (SC) allowed.

The high land cost in Hong Kong has a major effect on the planning and design of building developments. Practitioners invariably incline to use all permissible GFA and SC to generate layouts that maximize the usable floor space for individual flats i.e. maximises efficiency ratio.

Larger GFA means higher sales income, therefore exemption of GFA and/or SC calculations from specified green building features can be an attractive incentive to the building industry.

In February 2001, the Buildings Department, Lands Department and Planning Department jointly issued the Joint Practice Notes No.1, (JPN1) also known as the First Package of Incentives to Promote Green and Innovative Buildings. (Details of JPN1 is available @ Website: http://www.info.gov.hk/bd/). JPN1 advocated a holistic life cycle approach to building design: to maximize the use of natural renewable resources and recycled/green building material; to minimize the consumption of non-renewable energy; and to reduce construction and demolition waste. GFA and/or SC calculations are exempted for seven green features: balconies; wider common corridors and lift lobbies; communal sky gardens, communal podium gardens; acoustic fins; sunshades and reflectors; wing walls, wind catcher and funnels. A ceiling limit of 8% GFA exemption of the total permitted GFA is imposed to control the overall building bulk.

Balcony is one of the most popular green features because it provides space for greenery and recreation for the occupants. It enhances the use of natural lighting and ventilation, if properly designed it may also act as a noise barrier.

On face value there is nothing particularly green about wider common corridors and lift lobby, but in practice such common areas are squeezed to the bare minimal dimensions and stuck in the window-less core of a building. The interplay of efficiency ratio between common areas and usable floor space often relegate the former into mean and undesirable space in order to boost the usable floor space for individual flats. A more generous and naturally ventilated common area provides greater ease in down-to-earth activities like furniture removal.

Communal sky gardens provide recreational space at various levels of a building. They help in creating open vista and relief the walling effects of back-to-back, shoulder-to-shoulder configuration of our urban fabric.

In February 2002, Joint Practice Note No.2 (JPN2) the Second Package of Incentives to Promote Green and Innovative Buildings surfaced. In essence this is a continuation of the green features to be exempted from GFA and/or SC calculations. This time round, five features were launched: non-structural prefabricated external walls; utility platforms; mail delivery rooms with mailboxes; noise barriers; and communal sky gardens for non-residential buildings.

Construction and demolition waste amounts to some 40% of the total 17,900 tonnes of waste dumped into the landfill sites daily in Hong Kong. The use of non-structural prefabricated external walls helps to reduce construction waste. It alleviates the demand on landfill sites.

Utility platforms provide an area for laundry washing and clothes drying. Designated areas for these activities are noticeably lacking in most residential designs. By rendering GFA exemption to this feature, we help to reduce energy required in mechanical drying of clothes. We also improve the quality of living by encouraging provision for necessity-based design.

Joint Practice Note 1 and 2 provide incentives in form of gross floor area and site coverage exemption for green features that occupies floor space. Future incentive packages are in the pipeline, incentives being considered include gross floor area concessions for features that incur additional cost but may not require extra floor space, public recognition, open commendation and awards.

5. GREEN LABELLING SYSTEM

Although a number of assessment tools for environmentally friendly buildings are available both locally and international, it is necessary to device a unified and user friendly comprehensive assessment scheme tailor made for Hong Kong to deal with local characters such as high urban density, and hot and humid climate. We are in the process of commissioning a consultancy study that will provide grading or labelling to all buildings - existing and new in order to heighten the public's awareness of sustainability.

6. MODERNISE RULES AND REGULATIONS

Although the incentives offered in the Joint Practice Notes do not require any legislative change, the Buildings Department has embarked on a rigorous programme for a radical change of the current building laws and regulations as they are prescriptive in nature and are not conducive to green designs.

We envisage a modernized performance based code of practice and guidelines that enable the building professionals to exercise without inhibition their creativity in green designs. As part of the continual programme for the migration towards a performance based approach, existing codes will be reviewed and new codes will be introduced. A number of studies such as fire engineering, lighting and ventilation requirements, drainage etc. are already being carried out to provide performance-based standards in Hong Kong.

7. PARTNERSHIP WITH BUILDING PROFESSIONALS AND STAKEHOLDERS

The Buildings Department adopts a market-driven approach to promote green buildings. The department seeks to be a supportive regulator and proactive facilitator to encourage the construction of green and innovative buildings. Wide and continual consultation and communication with various sectors of the building industry are vital in ensuring successful implementation of the green building policies. The positive reception of the first and second

packages of incentives was reflected in the number of green submissions received. From February 2001 to March 2002, we have given approval to 94 building plans featuring one or more green features.

The developers need to pay premium for the exemption of GFA, therefore these incentives are by no means carte blanche free subsidies. Despite additional financial investment warranted from developers, they must have found our incentives attractive enough to want to continue in implementing these green features. Conversely, we do not consider incentives so given as revenue forgone for the government.

8. CONCLUSION

As a forward looking government department of the Hong Kong Special Administrative Region, the Buildings Department takes a proactive role in promoting green buildings and assume the role of a facilitating regulator. With no revenue foregone for the government and no additional human resources, we have been able to put forward a full range of comprehensive and coordinated strategies on green buildings to mobilise the market force by lever action.

Although the momentum of the green building movement is gaining pace, it is only a small step in the direction of a sustainable city. It is important to continue with our mission with an open mind and work hand in glove with the building industry to build a city that we can be proud of for years to come.

Sustainable Housing and Human Well-being

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INTRODUCTION

"Buildings have lives in time, and those lives are intimately connected with the lives of the people who use them" (Waddy 1990, p.xi).

"Between the world and our idea of the world is a fascinating kink. Architecture, we imagine, is permanent. And so our buildings thwart us. Because they discount time, they misuse time. Almost no buildings adapt well. They're *designed* not to adapt; also budgeted and financed not to, maintained not to, regulated and taxed not to, even remodelled not to" (Brand 1997, p2 and p210).

"A return to the room as a module for residential design is a necessary step towards creating resilient space" (Moudon 1986, p188).

These three quotations, the first by an historian, the second by an architect and the last by a town planner, express much of what we want to say in this paper. The central issue is the sustainability of housing in the face of changing circumstances.

The architect points to a systemic problem in the way many societies build houses – in pursuit of permanence our buildings are designed *to resist change*, whereas what we need in the pursuit of sustainability is a housing stock designed *to accommodate change*. The town planner's perspective is that housing is treated as a politicised game in which the *smallest* planning unit is a whole house or apartment. In this way of thinking, any house is better than no house at all – a principle that is perhaps right for third-world countries with a chronic shortage of basic shelter, but overlooks the question of how well the house serves its occupants over time. Moudon redirects our attention from providing shelter to providing nurture, where the point of debate is the room. The common theme here is 'resilient' planning, meaning that the house suits a wider range of household types, and can be easily adapted to suit the changing needs of its occupants.

Although none of the authors mentioned above are writing specifically on the subject of sustainability, their ideas help redefine what it means to provide sustainable housing. Much of the literature on sustainability is focused on the goal of a planet that is continuously capable of *keeping going* and *providing nourishment* to all forms of life. In this paper we want to shift attention to a different scale in thinking about sustainability – the individual person, individual household, and the neighbourhood. In microcosm, people and households (and neighbourhoods) also need to *keep going,* and be *nourished* in body and mind. This is what we mean by the word 'well-being'. The Shorter Oxford defines well-being as*: a state of being or doing well in life; (being in a) happy, healthy and prosperous condition* As one of

life's fundamental needs, housing has the potential to support or deny the wellbeing of individuals and groups of people in households.

Our underlying belief is that sustainable housing and human well-being are inseparable concepts. To start this discussion, we begin with a brief overview of the housing situation in New Zealand and characterise the problems from a humanist perspective. Many of the problems we mention will resonate with readers from other countries because, as Hamdi 1991 suggests, housing problems are universal in nature. We then outline the physical factors in housing that influence human well-being and go on to suggest some directions for achieving the sustainable, affordable and desirable house – in short, the 'well-tempered' house.

HOUSING IN NEW ZEALAND

To the casual observer, New Zealand might seem well housed, having a population of only a little more than 3 million inhabitants, a temperate climate, abundant fertile land and extensive renewable forest resources. The reality, however, is that New Zealand, has a fragile economy, increasing poverty and homelessness, and an aging stock of substandard and inappropriate houses. Like many countries in the world, New Zealand is finding it *increasingly* difficult to provide decent housing that is affordable. Waldergrave (1994) estimated that some 5% of all households in the country were in desperate need of housing of any kind that they could afford. A much larger proportion of the population live in houses that, instead of supporting their well-being, are actually a serious *threat* to their well-being.

How is it that a country with such a small population, and as environmentally blessed as New Zealand is, cannot find solutions? Or can it? And if solutions can be found here, to what extent would the lessons learned be useful in other countries? We start with a brief history.

The 'State House' era

In 1905, some sixty years after colonists started arriving on these shores, the government set about constructing 'State houses' for workers. Over the next 80 years, the New Zealand Housing Corporation constructed or helped finance an estimated 15% to 20% of the stock of domestic units in the country. About 140 different house designs were developed in an ongoing attempt to respond to changing social and economic conditions. However, at heart most State houses were attempts to meet an Arcadian ideal of a well-constructed stand-alone house for a family of two parents and two or three children, in suburbs adjacent to countryside where the children could roam free and safe. The dream extended to land on which the house was set - a quarter of an acre in area (approximately 1000 square metres), sufficient to grow fruit and vegetables for the family. Most State house properties were in fact rented and occupied by nuclear families and many of those people did lead a life that, outwardly at least, resembled the dream (Ferguson 1994, Fill 1984).

Government involvement in housing peaked in the 1960s and slowly declined from that time. Ironically, as involvement by the State declined, the need for a coordinated re-thinking of the Arcadian dream grew. This is because the demands for housing became increasingly diverse, as society in New Zealand changed. The typical three bedroom suburban house of the dream was (and is) no longer suitable for the rapidly shifting demographic make-up and distribution of the New Zealand population. Factors driving this change include: population growth (especially inflows of people from other Pacific nations), migration from rural to urban centres, the break-up of family units including a marked increase in the number of small households, the rapidly increasing costs of being a student, solo parenting (especially among teenage mothers), extended families and multiple family households, unexpected and short-

term changes in the composition of household units, de-institutionalisation of people with psychiatric and intellectual disabilities, unemployment, increased life expectancy and ageing.

Housing problems in the post-State House era

Waldergrave, 1994 estimated that the number of households experiencing serious housing problems doubled during a five year period around the early 90s when the government's housing reforms were being implemented. 'Serious' problems include homelessness, poor health and illness, family and individual stress problems including violence, effects on children's growth and education, transience and ethnic and other forms of social discrimination (Howden-Chapman 2001,). By the 1990s, when the government began selling off state-owned houses rather than building them, and began charging market rents rather than subsidising the costs for low income households, the country had *two* housing problems, not one. The old and persistent problem of *insufficient* low-cost housing remained, and was joined by a new problem – an increasingly *inappropriate* housing stock.

Recent research into New Zealand housing provides significant evidence that a number of aspects of housing can affect the health and development of the members of the household. These include: the physical structure and condition of the house; the area surrounding the house; whether the house is rented or owned; the number of occupants and the way in which the occupants live in their house (Howden-Chapman. 2001). Because of New Zealand's high rainfall and relative humidity, and the light-weight uninsulated construction of most pre-1970s houses, surveys have consistently shown a problem with cold and draughts, excess condensation, dampness and mould. Crowding has become a major public health problem in recent years, particularly among Pacific Island communities now living in New Zealand. The high incidence of crowding among Pacific people is likely to be the result of two forces: one is that Pacific people like to live in extended families, and the other is that many families move into one house to economise on the rent. As most available houses in the lower price bracket have been designed for the average family of two adults and two children, living with an extended family or several families can be problematic – and dangerous to health. For example, several studies (eg. McNicholas 2000) show conclusively that unsuitable housing is one of the critical material factors in the unabating and devastating epidemic of communicable and respiratory disease, among children in New Zealand

A case profile

We can best illustrate some of the current issues with housing by outlining a case. An extended family, comprising a couple with three young children (two boys and a girl), grandmother, and adult male cousin, recently migrated from another Pacific nation. After a stressful period of months staying with some distant relatives, they move into an outer-suburban house. Two of the adults have employment, one regular, and the other short-term. Rental costs are about 35% to 40% of the household income, reduced to 25% after the receipt of government subsidies. The single-storey, stand-alone house has three bedrooms, one bathroom, a water closet, a small laundry room, and an open-plan living area. The living area has a basic kitchen, an alcove space intended for a dining table, and a lounge area. Outside, there is a single garage and a small shed. There is a front 'garden' and a back 'yard', both mainly untended grass, weeds, and a few shrubs. The timber-framed weatherboard house has 'seen life', and looks untidy, but is structurally sound. However, there is no insulation in the walls, floor or ceiling space, there is no mechanical ventilation of kitchen, bathroom or laundry, and no built-in heating system. Water is heated by electricity in a poorly insulated storage tank. The window frames are aluminium, with single glazing. The largest windows

are in the living area that, in keeping with convention, faces the street. This happens to be the facade that receives least sun.

The first difficulty is over sleeping arrangements. The parents sleep in one bedroom with the youngest child; the grandmother occupies one of the other bedrooms, and the third bedroom is for the two boys. Initially, the cousin sets up a bed in the living room, but later he moves into the garage which he finds very cold and somewhat degrading, but it provides privacy and space. Over some years, various changes in the household put further stress on the sleeping arrangements. As the young girl grows up it is no longer appropriate for her to sleep in the same room as her parents, but as it is culturally unacceptable for her to sleep in a bedroom with her brothers, she moves her bed and possessions in with her grandmother. This makes the grandmother grumpy. Then the household is extended further by the arrival of a teenage girl, a niece. This causes a crisis that is resolved by moving the two girls into the bedroom previously occupied by the boys. One of the boys moves into the shed in the garden, and the other moves permanently into the dining alcove. This set-up places various stresses on members of the household due to lack of privacy and lack of space for normal activities. The boys' education starts to suffer as they have no space or support at home for their studies, their sense of self-worth goes down, and they start to exhibit behavioural problems. The children and young adult members of the household do not invite their friends home, (except very occasionally when the outside yard is used for cooking and social gathering), so they tend to meet on the streets in town and get up to mischief. To make matters worse, the household has a cultural obligation to welcome guests into their house, some of whom stay for days or weeks at a time. When this happens, the living room becomes a dormitory.

In this house, the arrangements for personal hygiene are also very problematic. The cultural norm for many Pacific peoples is for males and females to use separate facilities. Consequently the single bathroom is not only the cause of friction over delays in getting to use it, but quite serious stress from having to over-ride the cultural imperative of gender separation. A similarly insidious problem is that the door to the water closet is close to and visible from a habitable part of the house.

To house is cold, so to heat it at least cost, the household buys an non-flued gas heater using bottled gas as fuel. This type of heater produces large quantities of water vapour that gets trapped inside during cold spells when windows and doors are kept tightly shut. As a result of this heating-generated moisture, together with moisture from cooking and from washing, lack of adequate ventilation, lack of insulation, and the high-humidity climate, the house is permanently damp in winter. Moulds and various micro-organisms flourish. This household is fortunate in that none of its members become victim to one of a range of respiratory diseases that have serious, sometimes fatal consequences (Crane 1998).

Ideally, this household would either move to a more appropriate house, or alter the house to provide better for their needs for space, privacy, warmth, dryness, growth, respect for others, self-esteem, hosting guests, etc. The fact that they do not is partly through lack of money and partly because the building is difficult to adapt. The rooms themselves are not sufficiently large to allow for a wide range of internal arrangements and uses. The building is not designed with change in mind, and relative to its capital value it would be difficult and expensive to alter. . The landlord is unwilling to spend money to make the building more suitable to a particular tenant, and in any case the tenant could not afford the extra rent.

Overall, this household is in stress, mentally, spiritually and physically, *due to the house they live in.* Although the household described in this case is but one of many kinds of household (that differ by size, gender, culture, interpersonal relationship, age, income, and so forth), the ingredients of the problem are nevertheless typical of many houses and households in New Zealand. The case illustrates the point that overcrowding and consequential health problems happen when economic pressures coincide with a lack of space, poor facilities and services, and inappropriate planning.

In the last section of this paper, we look at the physical basis of a 'well-tempered' house and suggest one design approach that might meet Brand's call for adaptability, Waddy's challenge of houses that connect intimately with the lives of the people in them, and Moudon's idea of the room as a module of residential design.

THE WELL-TEMPERED HOUSE

In earlier work, based on a foundation of research in the serviceability of buildings (Davis et al. 1993) and a reading of the housing literature, Gray et al. 2001 concluded that to meet the requirements of good practice, housing has to be *affordable*, *sustainable,* and *serviceable.* In *best* practice, the three conditions are welded together and work as a unit. Table 1 is adapted from that work ands attempts to summarise the more important physical features of a house that influence occupants' well-being.

Space: sufficient space and facilities (inside and outside) for a wide range of individual and group functions and activities, including space for furniture, circulation, and storage of food and belongings; space for guests and hosting activities.
Layout: organisation of house elements and spaces to suit cultural and social norms, and the reasonable needs of occupants for privacy; capacity to arrange space (inside and outside) for rituals (eg. food sharing), major events (eg a death in the family) and celebrations (eg. a wedding party).
Equipment: fixtures, equipment, machines etc. that support basic household activities (or, at a reduced level of performance, the provision for later installation of equipment).
Adaptability: space, layout and equipment (in combination) that can be easily and inexpensively adapted to different needs and preferences within a household and between different households; capacity for more major change such as additions or internal alterations; rooms that are sized and proportioned to suit a wide range of options for occupancy/activity.
Health and safety: construction of non-toxic materials; warm and dry throughout the year; active and passive ventilation systems; easy to clean and keep clean; physical and visual access to the outside for outlook, air, sunlight; adequate and culturally appropriate facilities for personal hygiene; provision for fire safety (eg smoke alarms).
Tenure: sense of possession and control; secure tenancy, either by ownership or equivalent security of tenure; secure against unwanted entry and intrusion; features of building and land that enable the regulation of privacy.
Location: in a culturally and socially appropriate neighbourhood; proximity to community services (schools, shops etc); proximity to places of employment, or cheap transport to work
Pleasure: Features and qualities of a house and surroundings that are uplifting, give pleasure (eg. sunshine, space for hobbies, gardening, pets); opportunity for self-expression and display of identity.

Table 1 Ingredients of the well-tempered house

Design for well-being and sustainability

Figure 1 illustrates how a house, suitably organised, might be easily adapted to the changing needs of a family over a lifetime (or the various needs of different households at one time). Eight lifestyle situations are depicted (diagrams a to g). For example, imagine a young couple who buy a cheap three-bedroom house that they convert into two self-contained adjoining apartments, connected by a fire-rated, sound-proofed lockable door (or it could have been a removable wall section). Alternatively, the couple might build a new house arranged this way. They begin occupancy by moving into the house when the builders have completed all but the interior decoration, and while living in the house they work hard to complete first the larger unit, which they then let, and then the smaller unit, which they already occupy. Diagram (a) shows this situation, and the remaining seven diagrams show how they use the house through seven distinct periods in their life.

L = Living B = Bed O = Office 1 = unit 1 (1 bedroom) 2 = unit 2 (2 bedrooms)

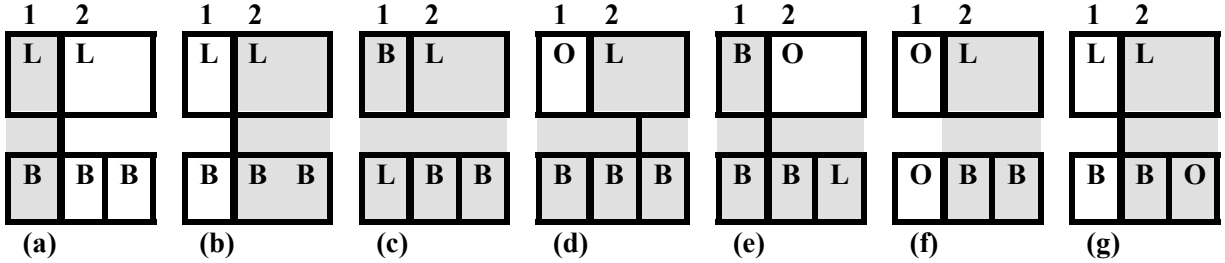

Diagram (a): Young couple, no children live in #1 and rent out #2. After two years a baby is born. They continue to live in #1 with the baby but give notice to the tenants in #2.

Diagram (b): Couple and one child move into #2, and let #1. A second baby is born in three years, and again they give notice to the tenants in the adjoining apartment, allowing them plenty of time to find alternative accommodation.

Diagram (c): The couple and their two children occupy the whole house for the first time. This is simply managed by opening the dividing door. Thanks to the income from rent, the repayment period of the mortgage is already greatly reduced. Both parents work and one is trying to start up a small business. There is enough room in the largest bedroom for a basic office set-up. Because of their busy life, the parents decide to take in a student who, in lieu of rent looks after the children after school some days. For five years the living room #1 is a bedroom and play area for the children. The small kitchen in #1, which was designed for easy removal, is partly dismantled and stored, but the sink bench and plumbing are left in place and the area is used for some years as an additional play space for the children. The smaller room in unit 1 is used as a second living room, with TV.

Diagram (d). With the children approaching their adolescence, the household changes again. Each child has a bedroom, and there is no longer a boarder living with the family. The business is starting to be successful and involve some serious amounts of work, so the 'living room' in #1 is converted into an office with one part-time employee working there.

Diagram (e): The children are now young adults starting their university education, and a lifestyle that exhausts their parents. Apartment #1 is given over to them entirely and the door between the two units is closed again (and locked!). The children occasionally visit the parents next door. The parents use the 'living room' as office and a smaller room for their retreat space.

Diagram (f): The children graduate and leave home. Apartment #1 is now devoted to the business. Apartment #2 has a spare bedroom for grandchildren to stay overnight, and other visitors.

Diagram (g): One parent has died. The widow continues to live in Apartment #2, keeping up a small home office (the business is now in separate premises). Apartment #1 is again let for added income. Later, as the remaining parent ages, this apartment is occupied by a companion/caregiver.

Figure 1 Adaptations of the same two-unt/3 bedroom house for different types of household

Measuring well-being

We suggested earlier that the literature on sustainability concentrates on factors for which there are standard units of measure, at the expense of those factors for which there are no units of measure, but that may be equally significant. To overcome this difficulty, Davis et al. 1993 developed a tool known as the "Serviceability Scales". With this tool, designed for rating the serviceability of offices, various *combinations* of factors (with and without units of measure in common) may be compared on a nine-point scale. We are in process adapting this tool for use in measuring and comparing the multitude of factors involved in affordable, sustainable and serviceable housing. Rather than describe it here, we refer readers to Gray et al. 2001, or ask that they contact the authors.

CONCLUSION

New Zealand has a growing need for low-cost housing, but the seriousness of this problem should not overshadow another pressing problem, which is that a significant proportion of the existing housing stock is unsuitable, or unhealthy or both. Certain aspects of housing can affect the health and development of the occupants. These include *physical* aspects such as cold and damp; *design* aspects such as room size and arrangement; and *occupancy* aspects of use such as tenure and overcrowding. The authors argue that such qualitative aspects of a house are instrumental to the householders' well-being. To sustain well-being over time the house has to adapt to changing requirements within a household, or the different requirements of changing households. Sustainability and well-being are inseparable concepts.

The authors identify eight 'ingredients' of a sustainable or 'well-tempered' house. Moudon's suggestion of *room* as the basis of resilient space is tested in the hypothetical case of a five roomed house that remains "intimately connected to the lives of people who use it" (Waddy 1990), through one generation. The results are encouraging, and lend further support to Brand's thesis that buildings will never endure as useful buildings unless they are *designed* to adapt.

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The "60L" Green Building

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THE BUILDING

60L is the leading example of green commercial building in Australia. The Green Building Partnership purchased the building at 60-66 Leicester Street Carlton Victoria for conversion to office units, in accordance with ecological sustainability principles within the commercial context.

The conversion of the building involves refurbishment of an existing 3 storey brick and timber and concrete office building, and the integrated construction of a new 4 storey concrete structure. The existing building was originally erected in 1876 and its uses have included a livery stable, furniture manufacturing and warehousing. Alterations have been made to the building 9 times during its history.

The $6.5 million development provides 3500 square metres of lettable floor space. The occupants are commercial and retail tenants.

The Australian Conservation Foundation has been a key participant in the planning and design of the building and is one of its first occupants, relocating its national headquarters to 60L.

The 60L Green Building demonstrates the commercial practicality of significant advances towards achieving environmental sustainability in all its aspects - design, documentation, construction, operation and management. Environmental values are embodied in the construction process and in the building itself, as well as in its use.

60L is designed around a central atrium with open stairs and landscaped features, including a roof garden, openable windows, shared facilities and meeting rooms, and bicycle parking.

GREEN BUILDING PRINCIPLES

The general principles that have been adopted for the 60L Green Building are to:

- Create a quality commercially viable building
- Minimise consumption and maximise reuse of resources
- Protect the natural environment by astute selection and use of materials
- Minimise energy consumption and greenhouse gas emissions

- Adopt environmentally sound and healthy work practices, both during construction and in occupancy, and

- Minimise mains water consumption and wastewater to sewer.

These principles have guided the development of the building and its tenancy agreements. The application of these principles requires considerable care in selection of materials and in the planning of all its aspects. Some aspects of the building require human solutions rather than technical solutions. Tenants sign a "green" lease and an Environmental Management Plan (EMP) is a significant element of building management.

The translation of these principles into design practicality has meant that the planning and designing of the building has taken longer than for similar commercial buildings, but the end result is significant savings for tenants.

Over 80% (3,500 square metres) of the gross building area (4,236 square metres) is lettable to commercial tenants.

GREEN BUILDING FEATURES

The 60L Green Building is a dynamic mix of new and refurbished, commercial and retail, economic and environmental. It will contain some specific features that combine to make it a unique and leading development:

- Materials efficiency, through maximising the use of existing materials and conducting environmental assessments on all new materials

- Energy efficiency, through effective demand management, natural ventilation and natural lighting

- Water efficiency, through rainwater use, efficient appliances and recycling of treated waste water, and

- Green management, through green leases, environmental management systems, user involvement in operation, creation of a building community and monitoring of post occupancy environmental performance.

The 60L Green Building has a greatly reduced environmental impact. It displays a model relationship between economic sense and environmental sense, and provides a real demonstration of the financial viability of more environmentally sustainable practices. It reduces the use of energy and materials, thereby providing lower operating and capital costs.

60L showcases environmental services and products, thereby stimulating similar approaches and facilitating the marketing of suppliers and tenants and their environmental solutions. It improves work environments, thereby enhancing occupant flexibility, satisfaction and productivity.

GREEN BUILDING PERFORMANCE

The 60L Green Building will sets significant new benchmarks for energy and greenhouse gas emissions and water efficiency in commercial buildings. It is expected that the occupants of the building will enjoy significant savings in comparison to a typical commercial development.

Annual Energy Costs

Electrical energy for lighting reduces by over 80%, for equipment by two thirds and for heating and cooling by about 60%. Expected savings are between 65 – over 70% per year compared with a conventional office building.

Annual CO2 Emissions

Use of electricity derived from non-fossil fuel sources ('green power') will enable savings approaching 100% in annual carbon dioxide emissions.

Annual Water Consumption

Over 500 kL of rainwater will be collected each year for use by taps, showers and basins. Water efficient fixtures and toilets reduces water consumption by about 60%. All of the waste water and sewerage generated on site is organically treated and recycled for toilet flushing and irrigation of landscape features and the roof garden. These measures will provide savings in average annual water consumption of between 90 – 95%.

Much of the comparative advantage of the 60L Green Building comes from giving building occupants a degree of control over their thermal and visual environment, and over their consumption of utilities. The building provides its occupants with the means to reduce the demand for energy and water services and the opportunity to behave in an ecologically responsible manner.

GREEN BUILDING AESTHETICS

The landscaping of 60L provides an aesthetic environment for the enjoyment of visitors and occupants. It uses site and treated water for irrigation and uses plants to cool the temperature and oxygenate the air. Landscape architecture is especially responsive to the environmental objectives and principles of the building.

The building entry includes a low linear flowing water feature with plants and appropriate fauna. Climbing plants extend to the full height of the building. The design incorporates an extended roof garden with plantings and social spaces.

Natural daylight is provided to all levels of the building together with natural ventilation whenever appropriate. The building interacts with its environment much more than conventional commercial buildings, and natural air and light are both be used to contribute to occupant comfort.

The building is commercially viable, with significant savings to its tenants and careful monitoring of both its economic and environmental performance. It provides a pleasant and

attractive setting for the occupants. It differs from a normal commercial building in its performance, its impact and how it feels.

A Green Compromise: Pilot Green School- Roxburgh Park, Melbourne, Australia

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INTRODUCTION

Providing models of environmental responsibility in school buildings is vital to set a good example for future generations. Students can experience and monitor the benefits of ecologically sustainable development (ESD) through the buildings and environment in which they learn. This paper explores the 'Green' design and development of a new school in Melbourne by Sinclair Knight Merz for the Department for Education and Training (DE&T).

Schools are relatively low consumers of energy and water due to comparatively limited occupancy times. Convincing government to invest extra capital in school buildings to achieve a more environmentally responsible building is difficult. As perceived cost benefits are minimal in schools our role as architects includes convincing our clients. Currently ESD principles are not part of the standard School Building Design Guidelines. This project may change that.

In Australia working with government funded school building budgets is challenging. Typically school buildings are built for A$825/m^{sq}, (approximately 70% of average costs for this building type in Victoria). Within the State Government sections of DE&T capital works funding is not directly linked to the departments who are responsible for on-going operating costs and funding in schools. Therefore any extra expenditure, such as increased insulation is generally not adopted unless additional funds (special factors) are approved.

SKM Design is the architectural arm of Sinclair Knight Merz, a multidisciplinary professional consulting company including water catchment and management services, building services engineers, civil engineers, quantity surveyors, planners etc. Roxburgh College is a new combined Primary / Secondary School on Melbourne's urban edge. The first three buildings of Stage 1 comprise a Junior School building, a Science Wing, and a Gymnasium for long term enrolment of 1100 students. The Pilot Green School provides an example of what can be achieved without actually having an ESD brief.

Increasingly expertise in ESD is perceived to be important as a marketing edge. Sinclair Knight Merz, originally an Engineering Consulting firm established over 30 years ago, has recognised the importance of ESD for the future and decided to document a pilot Green School as internal 'research and development' in a parallel process to the standard brief from DE&T, one of our major clients. (They are responsible for nearly 1600 schools.) Basic passive solar design principles are considered standard practice in this firm. However, on this

project the alternative ‘Green’ documentation was only undertaken after the buildings were essentially designed. Green ‘overlays’ and ‘add-ons’ were aimed to maximise energy and water conservation and demonstrate environmentally responsible use of materials. By documenting two versions reasonable cost comparisons could be made.

This of course contradicts the ideal approach of designing in a sustainable manner from the outset, which needs to be holistic, re-evaluating every design decision in terms of energy and water conservation and environmentally responsible use of materials. As alternative documentation was documented at Design Development stage there was limited opportunity to influence building form with respect to ESD principles. In the context of sophisticated examples of ESD these school buildings can only be considered ‘Pale Green’.

In Australia, relatively few new buildings are designed with ESD principles. Within these parameters and ever mindful of the budgetary constraints (the aim was for a maximum of 2% of the total building budget to be spent on ‘Green’ extras) the number of Green strategies implemented on this project has been a good start and a ‘first’ for a new Victorian Government School. We have had some indication that the more cost-effective elements may be implemented as a standard for government schools in future.

The ecological imperatives of learning by doing are important. (Blundel Jones 2001) As the educational value of more ‘visible’ Green elements were given a priority, cost / benefit analysis was not the only determinant in decisions about which of the Green options were implemented. After both standard and Green options were tendered, Green options up to a value of approximately 2% of building costs were implemented including Photo-voltaic cells, roof water harvesting, ventilation louvers and some alternative materials selections. More invisible ESD strategies like dual plumbing were not adopted for cost and regulatory reasons.

The environmental aims and initiatives of the project were to reduce operating costs and Greenhouse gas emission, reduce the water consumption, reduce ecological impact of the building and provide educational opportunities for staff and students. The way in which these initiatives were approached, and the extent to which they were adopted is outlined in more detail.

Reduction of Energy Use and Operating Costs

In many areas of Australia more energy is spent on keeping buildings cool than heating. However the need for air-conditioning of school buildings even in the tropics has been questioned (Prescott 2001). In more temperate climates like Melbourne no school building should require air-conditioning if adequate solar design principles are applied. However, even though government schools are not entitled to funding for air-conditioning, apart from computer labs, many schools opt to install air-conditioning with discretionary funds to alleviate summer heat in poorly designed buildings.

Roxburgh College was designed to include standard passive solar design principles of orientation, good cross ventilation, and sun control. This project will generally have double the standard insulation requirement for this region of Victoria (R1.5) for a total insulation value of R3.0. Insulation is a proven cost effective measure and will be made visible in the Science wing through a ‘truth’ window cutting through the wall. Increased insulation was applied to the classroom buildings but not the Gymnasium. Typically, the brief for a School Gymnasium is for an un-insulated, unlined un-ventilated building. Within these parameters, cooling is achieved through cross ventilation and stack effect cooling using louvers and ridge ventilation.

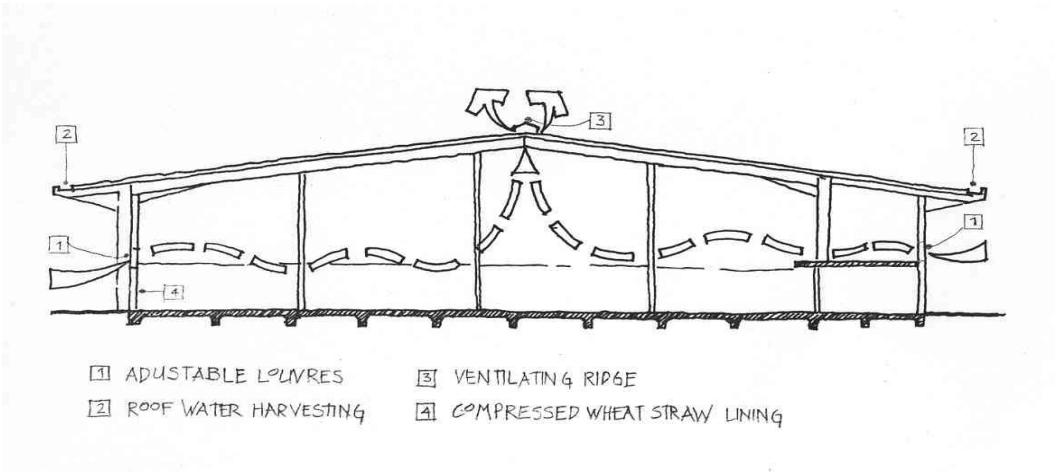

Figure 1 Cross Ventilation to Gymnasium

For the classroom buildings an alternative custom orb roof system (Ritek) was proposed for both its insulation properties, and its capacity to span up to 8 meters and cantilever half its span length. This is ideal for a bay of classrooms which typically are 7x7m modules and have a covered way to the entire length. This roof material is a lightweight stressed-skin roofing panel, bonded by polystyrene, with R values of 2.5 for a 125mm panel and R3.0 for a 140 mm panel. Designed for cyclone conditions the panel was proposed for classrooms, eliminating the need for a trussed roof structure, plasterboard ceiling linings and the framing and posts associated with the covered ways. However the material is more costly and with the complexity of the roof design (done prior to ESD documentation commencing) we anticipated that potential cost savings would be minimal. As the product is relatively unknown in Victoria it was generally highly priced by tenderers and could not be adopted. Nor were the simpler roof forms adopted, even though the reduced volumes would have brought about considerable heating savings as indicated by table below. (Figure 2)

Junior Classrooms	Heating Demand			Annual Gas Consumption			Green House
North Perimeter	**Green Design**	**Original Design**	**Saving (kW)**	**Gas Saving (MJ/hr)**	**Saving Gas (MJ)**	**Cost Saving A$**	**Gas Emission**
Classroom 1	3.0	9	5.7	62	34,474	$276	2.1
Classroom 2	2.7	9	6.0	65	36,288	$290	2.2
Classroom 3	3.0	9	5.7	62	34,474	$276	2.1
Classroom 4	2.5	9	6.2	67	37,498	$300	2.2
Total	**11.2**	**36**	**24.8**	**268**	**149,990**	**$1,200**	**8.5**
South Perimeter							
Classroom 5	2.4	9	6.3	68	38,102	$305	2.3
Classroom 6	2.0	9	6.7	72	40,522	$324	2.4
Classroom 7	2.3	9	6.4	69	38,707	$310	2.3
Classroom 8	2.1	9	6.6	71	39,917	$319	2.4
Total	**8.8**	**36**	**27.2**	**294**	**164,506**	**$1,316**	**9.4**
Building Total	**20.0**	**72**	**52.0**	**562**	**314,496**	**$2,516**	**17.9**

Green System Capital Costs = $23,000 including Gas pipe reticulation
Original System Capital Costs = $40,000 including gas pipe reticulation

Savings in Capital Cost = $32,000
Based on Fgreen Design with simplified roof & reduced volumes

Figure 2 Comparison of Heating Needs for Standard & Green Design Junior School

The cost of electricity is generally much lower in Australia than in Europe. Energy efficient lighting design in this project included zoned lighting to supplement light requirements with natural day-lighting. Energy efficient fittings were investigated. In Australia within school hours from 9-3, natural day-lighting can supplant much of the need for artificial lighting on sunny days. Cost / benefit analysis of more sophisticated light fittings were shown to be of little significance.

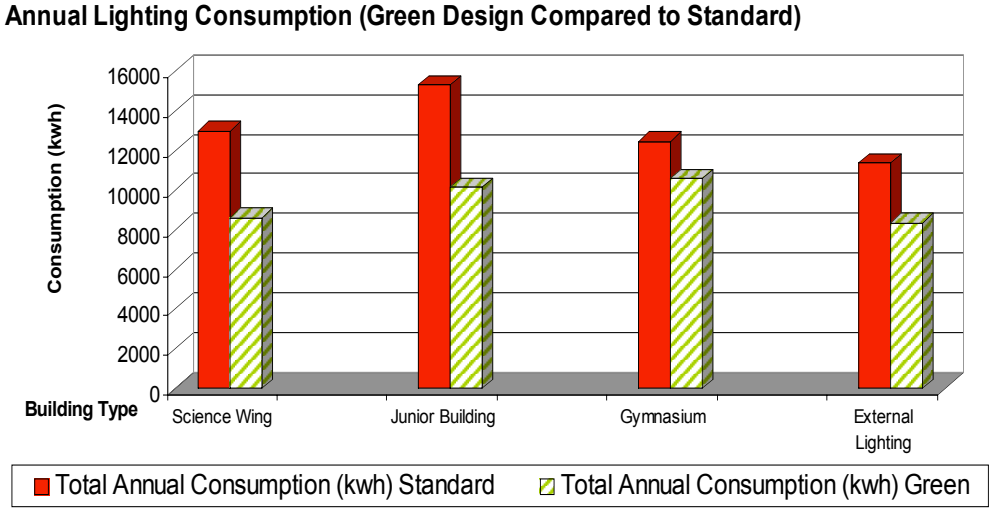

Figure 3 Comparison of Standard T5 and more efficient T8 light fittings

For the standard lighting design with T8 fluor type fittings, total annual power consumption for school lighting was estimated to be 52114 (Kwh) at a cost of A$1183 per annum.
For the more efficient T5 fittings total annual power consumption was reduced to 37713(Kwh) at a reduced cost of $A855 per annum. The additional cost of the fittings is approximately A$10,000 [1.] – This equates to a pay back period of approximately 36 years, due to the limited operating hours of the school context.

Reduction of Greenhouse Gas Emissions by Responsible Material Selection
Low embodied energy material, like timber rather than steel was proposed. However due to Government Schools' demand for low maintenance finishes external applications are limited. Timber posts to covered ways for example are generally not considered acceptable unless the school client specifically undertakes to make allowances and commitment to regular maintenance. All Medium Density Fibreboard (MDF) was to be eliminated except pre-finished MDF boards to joinery. Smaller sections of timber trims were proposed for skirting and architrave sections. As a substitute for impact resistant MDF internal wall linings, a recycled wheat-straw board was specified. Linoleum was specified instead of vinyl to reduce PVC. However vinyl, which is generally cheaper and lower maintenance than linoleum was adopted.

Reduction of Water Consumption
A number of options were explored including roof water harvesting for grey-water re-use. Regulatory controls for water use in schools require water collected from the roof to have Ultra Violet treatment, even if it is only proposed for toilet flushing. Enforcement of this regulatory requirement varies. In rural areas, schools' drinking water is actually harvested off roofs and stored in the Australian iconic corrugated iron tanks, as a standard practice. This is

also typical for most households in the absence of town water connection. Arguably city roofs are potentially more contaminated and therefore not recommended for drinking. However with increasingly litigious environments, school policy is fairly conservative and roof water is only permitted for irrigation purposes.

Landscaping has been generally designed not to require irrigation, through selection of native and indigenous species. Playing fields in this region require irrigation. During establishment stages irrigation will also speed up plant growth designed to provide shade and sun control to east and west facing windows. The water harvested will be stored in above ground storage tanks making water conservation highly visible. Irrigation will be activated by a 'smart' irrigation system, Micromet. This not only measures the moisture content in the ground but also links into the weather forecast. So, if rain is predicted for the following day and soil moisture content is marginal, irrigation requirements will be measured accordingly.

Site design to make use of site runoff water includes replacing the traditional kerb and channel around car parking areas with agricultural drains to planting strips. This ensures plants benefit from site run-off and water being discharged to off-site storm-water collection is minimised.

Other water saving devices include dual flush cisterns requiring three or six litres of water per flush, which are now mandatory in most parts of Australia. Compared to the old single flush cisterns, this alone constitutes an 70% saving in water use for toilet flushing. In 1985, 8% of Victoria households had a dual flush toilet. This increased to 68% in 2000. [2] Additionally water flow control valves to all tap and shower fixtures are specified to conserve water.

Provision of Education Opportunities for Staff and Students

In order for these water saving measures to be meaningful for students and staff accessible monitors will be installed in the science wing. This will enable student readings to be incorporated into environmental curriculum.

Photo-voltaic cells, subsidised by a Commonwealth Government grant from the Australian Greenhouse Office (AGO) program were included for their potential to provide an educational example, rather than for substantial energy saving benefits. The Photo-Voltaic Rebate Program for Community Buildings objectives are to: reduce Greenhouse Gas Emissions, assist in the development of the Australian Photo-Voltaic industry and increase public awareness of Renewable Energy. Eligibility for the rebates depends on an assessment of relative educational and interpretative merits of a proposal, with schools generally fitting the criteria. The rebate is capped to a maximum of A$10,000 with a minimum 450 Watt peak output to a grid connected system required.

These photo-voltaic panels will be installed on the Science wing roof with the meter located for student reading within the classroom. This enables the system to be incorporated into the teaching curriculum as appropriate, providing a 'hands on' example of alternative energy in action. The Sustainable Energy Authority Victoria (SEAV) provided excellent advice and support with model technical specifications for PV cell installation. (still not within every architects range of expertise).

Tendering

Standard and Green documentation were tendered with some surprising results. The two lowest tenderers addressed the Green options most comprehensively. Some of the products proposed were unknown to builders. Some alternative finishes like recycled rubber pin-up

boards were proposed. This was priced higher than standard pinup-boards by the contracted builder but lower by another tenderer. Surprisingly reduced size timber skirting (trims to floor junction) and architraves (window and door surrounds) in lieu of MDF were priced lower. This reflects an increasing trend to avoid MDF cutting on site. Since the potential of health problems from inhaling MDF dust has been established, special cutting rooms with exhaust systems are required on site and clearly more costly for builders. MDF is still significantly cheaper than timber from a material cost point of view.

CONCLUSION

Clearly many compromises were made. Schools are one of the most challenging projects but also the most worthwhile for future generations. Within the cost and regulatory parameters of the project, taking the steps to implement Green initiatives in a new Victorian Government school is a first. We look forward taking the lessons learned further, build more sustainable buildings in darker shades of Green, deep Green.

ESD Team for Pilot Green School:

Project Director	John Peirce
Electrical Consultant	Mohamed Hamza
Mechanical Consultant	Sam Baraz
Hydraulic / Civil	Tony di Giuseppe
ESD Architect	Anna Lindstad
Landscape Architect	Tanya Court, Pattus & Pettus

Notes

1. Annual consumption for 377 No. light fittings is based on 6 hours per day x 5 days / week x 40 weeks per year.
2. www.savewater.com.au Australia's Leading Source on Water Conservation

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Sustainability, architecture and comfort: a biotechnological model of environmental adaptation.

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1. INTRODUCTION: HUMAN RESPONSES TO THE ENVIRONMENT AND SUSTAINABILITY

Emergence of environmental building systems (heating, lighting and ventilation) followed closely progress in technology. Initially, indoor environmental controls were very simple and relied on natural phenomena such as convection currents. That was complemented by behaviour adjusted to prevalent conditions. As Forwood (1980: 146) indicated:

> Apart from minor applications of energy [...], the only other form of environmental control available to the occupants of these "pre-technological" buildings was the adaptation of [their] life style and behaviour to suit a particular climate.

As soon, however, as various forms of energy and devices using them became available, they have been employed to deliver light, air, heat and moisture in order to modify parameters of indoor environments. The introduction of technological developments to buildings meant that more or less satisfactory conditions could be maintained *irrespective* of external conditions and the form or nature of the built environment. Nowadays, the situation should be described as our complete reliance on various building service systems (ibid.), which also results in a heavy environmental cost associated with the consequent exponential growth in buildings energy requirements. However, humans are able and do adjust to a broad range of climatic conditions.

Architecture, by its very nature, uses energy, alters the existing fabric and imposes a structural form upon others. A lot of effort appears to be put these days into bringing environment-friendly, energy-efficient buildings and developments under a banner of 'sustainability'. 'Sustainable architecture' represents a transition to a more humane and natural environment. The overall objective of sustainable architecture may be expressed as the provision of high standards of thermal, acoustic and visual comfort, working with the environment rather than against it. 'Sustainable' buildings aim to lessen their impact on the environment through energy and resource efficiency. It follows that such buildings should respond to the environment in which they are built by taking full advantage of the useful climatic conditions at the site and eliminating or minimising the influence and effects of any undesirable phenomena. Architects should regain the responsibility for indoor environment from HVAC engineers since their concern with machines and processes employing machines and energy rather than with human comfort made the latter a sort of a second–rated issue. Meanwhile, the fabric that architects deal with and the way they can use it, offers plenty of opportunities to modify and regulate the indoor environment of the building and ultimately — match needs and expectations of its occupants.

2. BUILT ENVIRONMENT AS AN ENVIRONMENTAL MODIFIER

Modern humans occupy virtually all of the Earth's non-aquatic biomes. This amazing expansion was possible not because humans display some unusual environmental adaptability, but because we have gained skills, experience, knowledge and technology to provide for all the required environmental modifications. It was possible because we can build. Historically, buildings have evolved from a basic form of a shelter, which provided a desired modification of a local climate (cf. Baker, 1993; Pearson, 1989). Even those early 'primitive' buildings enabled human 'colonisation' of vast areas despite their inconvenient climatic characteristics. In the process, however, people became highly dependent on those self-created artificial micro–environments. We are able to survive for any extended period of time only if relatively narrow–specified conditions are provided.

A set of the favourable environmental conditions shall be called the *environmental comfort*. Thermal comfort, believed to be a dominant problem in 'extreme' climates (eg. in the tropics, cf. Koenigsberger et al., 1973), encompasses problems related to acceptable conditions of heat exchange between a human body and its surroundings. However, it could be argued that for the purpose of modelling adaptive responses, it would be appropriate to include non-thermal factors, such as lighting and noise levels, or even smell and touch as well (cf. Radford, 1980, Pearson, 1989, and Tombazis, 1993). Forwood (1980: 150) noted:

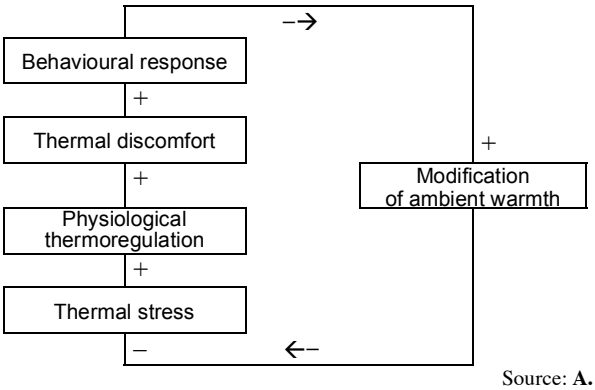
> All our senses are stimulated simultaneously. We feel warm or cool at the same time as we hear background noise, see the colour of surfaces and are aware of the quality and the quantity of light entering through windows.

In pre-technological era, indoor environmental comfort was accomplished by the use of specific designs. For instance, people in the tropics would build their villages to allow free air movement and good shading of individual houses. Large gable roofs, extensive overhangs, thick layer of insulating material used as a roof cover, lack of walls and elevated floors were all the design features typical of the zone. This response to local climate conditions could have been further enhanced by a number of behavioural adjustments.

From a physical processes' standpoint, a building and its environmental control systems are a microcosm of complexity. According to Forwood, achievement of better design standards requires an approach which "allows to model the interactions taking place between the building enclosure design variables and the performance parameters affecting the total physical environment" (1980: 150). High quality of the outcome will depend on harmony of all the elements interplaying with each other and with the building's environmental setting. That cannot be done by removing ourselves from those considerations. The objective of environmental control in buildings can be expressed as a broad strategy aiming at achievement of certain parameters *and* influencing perception of the environment towards its acceptance.

3. MODELS OF ENVIRONMENTAL ADAPTATION

Initially, it was believed that human thermal preferences are constant and free from external influence. In the 1960s, a series of climatic chamber experiments in the USA and Denmark (Fanger, 1973) resulted in a constancy hypothesis. Strongly supported by the influential American Society of Heating Refigeration and Air-conditioning Engineers (ASHRAE), it assumed a simple path of cause and effect for a practical purpose of determining people's behavioural responses (Figure 1).



Source: **A. Auliciems** *Thermal comfort* (1989)

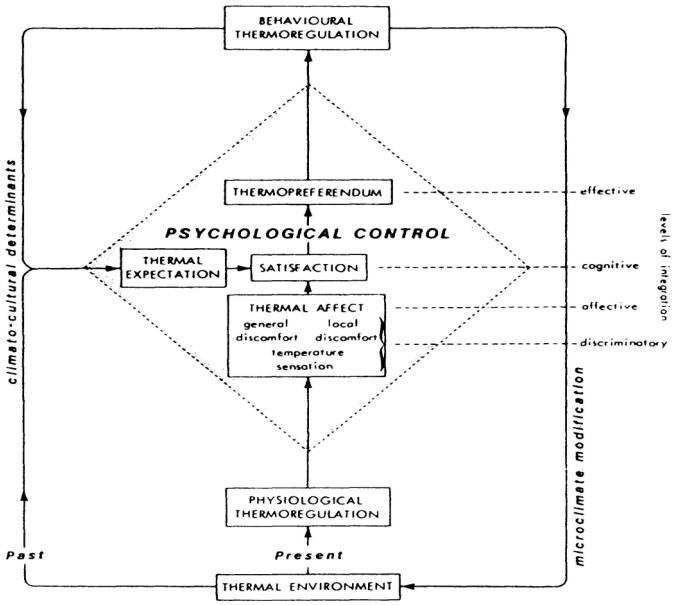
Figure 1. Simple path of cause and effect assumed in thermal constancy hypothesis.

Simplicity of the model in offering a prescription for 'optimal indoor conditions' was regarded both as a cultural advance and as an economic/technological advantage (Auliciems, 1989). However, the problem of human responses to environmental stimuli is much more complex than constancy model might suggest. For example, our bodies have a highly efficient mechanism providing temperature regulation. Temperature monitoring centre performs proportional control, rate control and possibly integrated control (Macpherson, 1980) of the body's thermal environment. Central sensors, located in the hypothalamus at the base of the brain, are supplemented with peripheral sensors in the skin or superficial subcutaneous tissue to ensure quick responses to identified needs. The important thing to note is that the peripheral sensors, by virtue of their cortical connections, make possible an intelligent *anticipatory* behavioural control of body temperature (ibid.).

As early as in the 1930s, a search for satisfactory measures of the relationship between the environment and the human body resulted in a number of thermodynamic equations, which subsequently led to establishing the 'thermal optimum' or 'neutral point' (Lee, 1956 as quoted by Venville, 1959). It was alleged that human physiology allows for very little (if any) variations of the standard comfort conditions. Studies from that period, however, too hastily concluded that it was possible to construct a universal formula, applicable to all humans. It is true to say that — because humans are homeotherms — heat balance of our bodies must be maintained over any significant period of time (Gagge, 1936 as quoted by Auliciems, 1972, cf. Macpherson, 1980). The heat balance equation formulated by Gagge described a mechanism by which the body exchanges heat with surroundings. Nevertheless, balance of the elements entered into the equation, while being a necessary condition for thermal comfort, is not a sufficient condition. All that can be said, according to Macpherson, is that "thermal comfort *seems* to be associated with low rates of energy expenditure" (ibid.: 22).

It should be stressed that laboratory techniques involving either experimentation or measurement of our responses are, taken alone, inadequate for comfort investigations. It is so because, by their nature, they ignore the interactive nature of the environment. Although we understand laws of physics, which determine the action of individual components (eg. heat, light and sound), we know very little about the apparent complexity of their interactions in the building environment situation. Mathematical models — used for that purpose — contain many simplifying assumptions, which render them useless except for the very simplest static cases while comfort should be considered dynamically (cf. Baker, 1993). Its parameters vary spatially in a building and appropriate application of such knowledge may be used to avoid discomfort. Occupants themselves can also take appropriate action to adjust passive controls (sun-shades, openings and others) to improve indoor conditions. Comfort parameters vary also in time and tend to influence occupants' perception in accord with seasonal and diurnal

changes. Behavioural adaptation (clothing, posture, activity etc.) can, in turn, influence perception of certain elements of comfort.



Source: **A. Auliciems** *Psycho-physiological criteria…* (1983)

Figure 2. Psycho-physiological Model of Thermoregulation suggested by Auliciems.

In the early 1980s, Standard ISO7730 of the International Standards Organisation (ISO) and ASHRAE's Standard 55–81 re-defined human thermal comfort as a 'certain state of mind, following subjective assessment of the current physical conditions'. Both the physiological thermoregulation and the mental attitude started being considered equally important in adapting to a given set of conditions and a possibility to influence comfort by utilising that 'subjective assessment' had to be incorporated in thermal modelling. A very significant step in that direction was taken when Psycho-physiological Model of Thermoregulation was proposed by A. Auliciems in 1969 (final version published in 1981, Figure 2). For over two decades it remained the most comprehensive representation of human responses to conditions in the surrounding environment. Its greatest advantage over 'purely physiological' models, which appeared to offer a rather inadequate explanation of great many comfort and discomfort manifestations, was that it proposed incorporating psychological control. The control is exercised at four levels of integration: discriminatory, affective, cognitive and effective. It also explained how techno-culturally based expectations and average outdoor conditions acted as a "negative feedback which attracts the thermal perceptual system's set point, thereby damping load error (discomfort/dissatisfaction) within the behavioural thermoregulatory system" (de Dear, 1994).

4. COMPARISON OF THE MODEL OF ENVIRONMENTAL ADAPTATION AND PSYCHO-PHYSIOLOGICAL MODEL OF THERMOREGULATION

The adaptation hypothesis developed by Auliciems explains how techno-culturally based expectations and average outdoor conditions combine with effective conditions of the physical environment (average outdoor conditions) to result in psychological assessment (comfort/satisfaction or discomfort/dissatisfaction) by the mind and physiological responses by the body. It can be argued that the building design also contributes to the mechanism of environmental adaptation. There is, for instance, evidence of the indoor temperatures within 'free–running' buildings, which people find comfortable or at least acceptable, being positively correlated with climatic conditions prevailing outdoors (Auliciems & de Dear, 1986, de Dear Brager & Cooper, 1997).

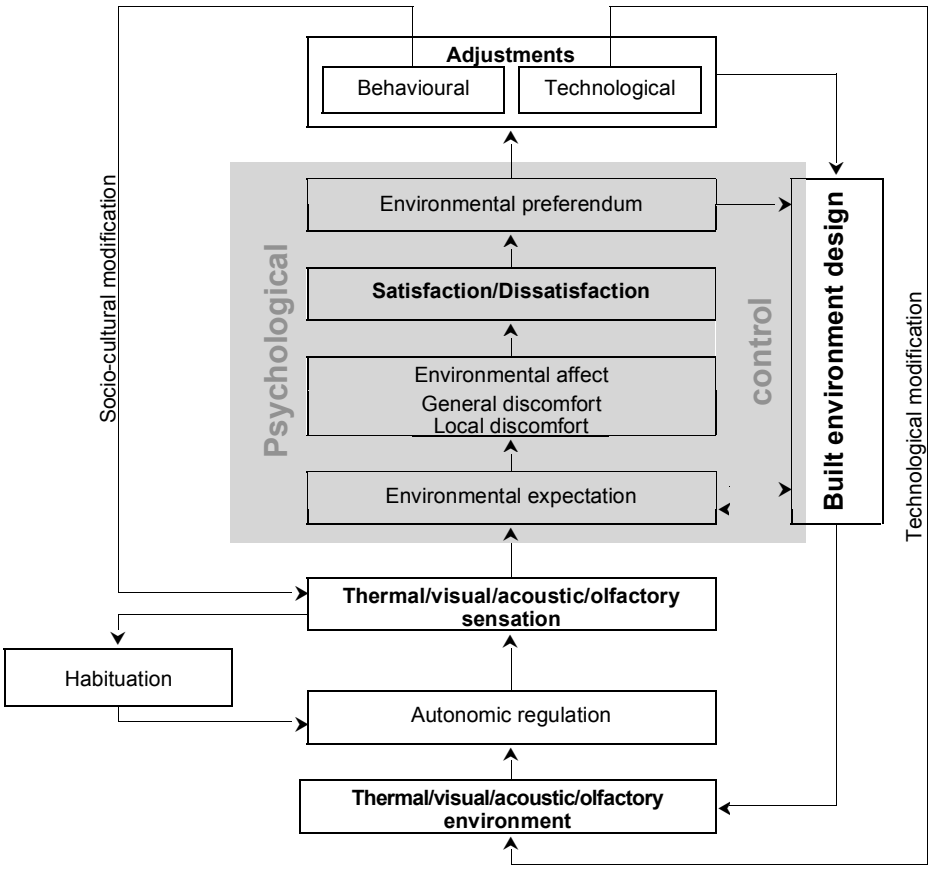


Figure 3. The Bio-technological Model of Environmental Adaptation: place of building design in processes of adaptation.

The diagram above (Figure 3) represents a schematic model of environmental adaptation. It aims at introducing building design into the Auliciems' model. The building design is here a means of modifying the environment and an environmental component, which in turn tends to influence human behaviour. The model consists of three loops: (technological) microclimate modification can take a path where adjustments are temporary (eg. shutting a window) or where space is (re-)designed for a more permanent change. Socio-cultural modifications are derived from and based on behavioural adjustments and can involve eg. dressing codes or activity patterns. Finally, habituation presents itself as a tight loop of physiological response to repeated stimuli. The model shows several different mechanisms which can be utilised to interact with environmental comfort. Technological adjustments, environmental expectations and environmental preferendum can become inputs and considerations in designing the built environments while the design outcome is clearly capable of modifying the environment as well as influencing our expectations about what we might experience.

5. CONCLUSION: SOME PRACTICAL IMPLICATIONS OF THE INTRODUCED CHANGES

One could suggest that building standards, which support universality and uniformity in determining thermal preferences, should be more flexible (performance–based) to accommodate different and ever changing needs. Baker (1993) also suggests that provision of proper building controls, understandable and accessible to the occupants, and contact with the external environment reinforces a kind of 'psychological acclimatisation'. The notion of "living natural" has been promoted by a number of physiologists and medical practitioners (cf.: Eaton, Shostak & Konner, 1989). They argue that it is healthier to make use of our

genetically inherited abilities and adjust to local conditions, than to expose ourselves to dangers related to the use of artificial environments. A lot can be achieved with the use of appropriate building design. At the moment, design of the built environment appears to be an interface between people and their environment that is largely neglected.

To enhance the results derived from design, a great deal of attention should be given to our behaviour. As demonstrated by the model, tolerance, education and design–derived perception of the environment can become means available to us within psychological control of our responses. Encouragement given to exposure to the natural environment can be a way to ensure that buildings' users would feel more comfortable while using them. They should be also convinced that the allowance given to the provided conditions serves the protection of the precious commodity and conservation of scarce resources.

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Striking an Effective Balance: Developing Sustainable Residential Homes Through Optimization

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1. INTRODUCTION

The building industry has renewed its efforts to create more innovative ways to meet society's needs in a more sustainable manner. However, while many corporations may boast of the benefits to both productivity and the environment that the incorporation of some of the options for more sustainable architecture has produced (Romm, 1999), the residential sector has been trailing in the revolution. This is largely due to the perception that homeowners experience little personal gain by incorporating similar design options that often involve larger capital costs. In this light, the paper discusses the potential use of economically driven optimization as a decision support tool to effect increased sustainability in residential homes.

The paper starts with a discussion of the current issues involved in sustainable architecture. A framework based on a set of sustainability indicators and targets assessing different design strategies in residential homes is introduced. An optimization model designed to minimize life cycle cost, subject to a set of environmental impact constraints based on the sustainability indicators and targets, is put forward. A four bedroom residential home in Ottawa, Canada is used as a case study to illustrate the mechanics of the model and to demonstrate its potential as an effective and practical tool in the sustainable decision making process. Finally, an outline for future work is presented.

2. OPTIMIZATION AS A WAY FORWARD

2.1 Sustainability: The Balancing Act

Sustainability has been defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). Sustainable architecture has evolved in recent practice into ecologically sensitive modes of design, construction and operation geared towards producing communities that are less damaging to the natural environment, and thereby less of an infringement on the rights of future generations to draw upon Earth's resources. However, this approach has been more aptly labeled as 'green' architecture. In addition to environmental issues, 'sustainable' architecture should also encompass two other equally important facets: social equity issues and economic issues. In other words, green architecture is not sustainable unless it is available and affordable to all.

Unfortunately, in the industry today, green goals often conflict with the traditional tri-fold objective of minimizing construction time and cost while maximizing fitness for purpose. For example, the use of effective recycled aggregate and steel and the incorporation of higher percentages of fly ash in concrete may significantly increase the time and cost of construction if the building is to maintain an equivalent level of service. The need for an effective system of balancing these tradeoffs is immediately evident.

2.2 Sustainability: Indicators and Targets

Whereas the unit measures of time and cost have been universally accepted, and systems of specifying the level of service that a project meets have been well developed in the industry, an effective measure of 'greenness' remains elusive. Such measures must be incorporated into the design process in order to move towards sustainability.

While there have been efforts to reduce 'greenness' to a single metric for simplicity, there are compelling arguments against this approach. Though intended to capture multilateral improvement, relative weights and common metrics tend to be rather subjective. The relative value of a tree and a litre of crude oil, for example, may lend itself to an endless debate. A more appropriate approach may be to establish a region-specific ***set of indicators*** that together represent a movement towards greener architecture and select quantifiable ***targets*** that describe relevant sustainability goals.

2.3 Optimization as the Key

If affordability is used as the driving force in selecting the optimal combination of building components that meet or exceed the sustainability targets established, then the optimization model may be described as in Equation 1:

$$\text{Minimize } \Sigma_{\text{all J}} (C_J) \text{ subject to a set of constraints of the form } \Sigma_{\text{all J}} X_{IJ} \leq X_I^* \quad (1)$$

where,
C_J represents the life-cycle cost of component J
X_{IJ} represents the environmental impact, I, of component J and
X_I^* represents the sustainability target for environmental impact, I

This model effectively guides the designer towards achieving the sustainability targets that are the most cost effective, provides an indication of which targets are more difficult to achieve, and hence, highlights the areas in which further research and innovation are necessary.

3. OPTIMIZATION IN ACTION

3.1 The Tools

For the optimization approach outlined to be meaningful, a comprehensive life-cycle inventory database is needed. Additionally, there must be a system of assigning life-cycle costs to these components. For this analysis, the necessary data is imported from many sources and conventional linear optimization software is used. The following describes the main building blocks of the optimization model.

3.1.1 ATHENA™. The ATHENA Sustainable Materials Institute (2002) has developed a life-cycle inventory package that allows its users to compare most of the common building materials and typical construction assemblies currently used in North America. The user inputs key building descriptors, selects from an array of building assemblies to describe a

three-dimensional structure and chooses the one of nine North American urban centres that best represents the building's location. Based on material or product quantities associated with these building assemblies, the model returns a detailed life-cycle inventory for a given design. The user may then compare specific impacts such as total CO_2 emissions from extraction, production, construction and disposal of the assembly or aggregated indices such as global warming potential (GWP) and water toxicity index.

3.1.2 HOT2000. The Buildings Group at Natural Resources Canada (2002) has developed a program that uses the thermal effectiveness of a building and its components as a way of evaluating alternative designs. The evaluation method takes into account the passive solar heating owing to the building, and the operation and performance of the building's heating, ventilation and cooling systems.

3.1.3 Dodge Unit Cost Guide. Marshall and Swift (2001) provide a comprehensive list of building cost estimates. Material, labour and equipment costs with overhead and profit are taken into account and adjusted by local multipliers to account for regional differences throughout North America.

3.2 The Technique

For the purpose of analysis the house can be broken down into a set of five components: walls, roof, floor, doors/windows and insulation. Then two or three options for each of the components are proposed. For each option, costs and environmental impacts are derived for each of the five life cycle stages: raw material extraction, production, construction (including transportation), operation and disposal (Figure 1).

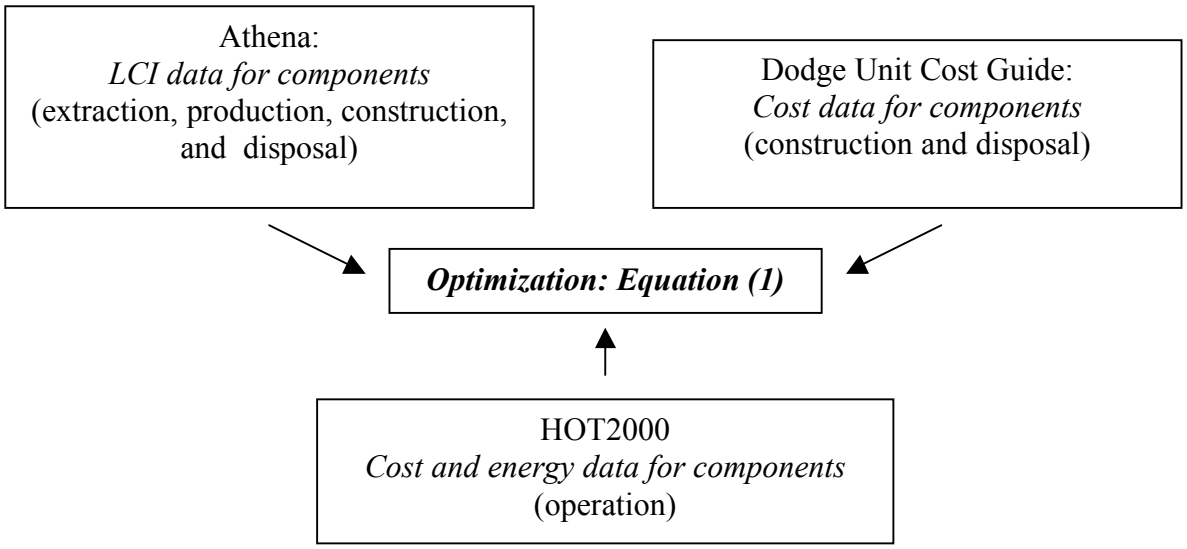

Figure 1 Methodology: Balancing Life-Cycle Cost and Life-Cycle Impact Through Optimization

3.3 Ottawa House – A Case Study

Through Natural Resources Canada, a four-bedroom, two-storey, detached, single-family house in Ottawa, Canada is used as a case study to demonstrate the mechanics of the model. The base house, used as a control in the example, is based on the geometry of Ottawa House. The wall is composed of 39mm x 89mm kiln dried wood studs, spaced 400mm apart, with 150mm thick fiberglass batt insulation, a 3mm thick polyethylene vapour barrier, 1/2"

moisture resistant gypsum board and brick cladding. The roof is a pre-engineered wood truss system with 12mm plywood decking, with insulation details similar to the walls. The ground floor consists of a wood joist and plywood decking system. The windows are double-glazed with wooden frames.

For alternative wall components, a 25 gauge, 39mm x 92mm steel wall and an 8" concrete block wall are considered. A flooring system of 39mm x 152mm steel joists and 12mm plywood decking is considered, as is a 20 MPA poured concrete floor. Open web steel joists and steel decking provide an alternative roofing system and the effect of low-emissivity, triple-glazed, argon filled windows is explored. An additional layer of expanded polystyrene insulation is also considered.

Using the Athena software, the options for each component are compared on the basis of the following summary indicators: embodied energy, solid waste generated, air pollution index, water pollution index, GWP and resources use. The Dodge Guide is used to estimate the costs of construction and demolition/disposal of the components. The energy use of the house as a unit is derived, using HOT2000, for each combination of options. The energy used over the design life of the building is translated into an estimate of causal global warming potential, using the ratio of the average electricity generation mix in Ontario and the associated emissions as outlined in Enviromega Inc. (2002), and cost, based on the 1997 Ottawa energy rates (NRCan, 2002), is compared to the base house for a more complete representation of these factors. For the purpose of this example, GWP is defined as in Equation 2. A target reduction of 10% in GWP for the home as a unit (all other environmental factors ignored) at minimum possible cost is assessed for the most optimal combination.

$$GWP\ (kg) = CO_2\ (kg) + (NO_X\ (g) \times 296 + CH_4\ (g) \times 23) / 1000 \qquad (2)$$

3.4 Results

The results indicate that a 10% (124, 420 tonne) reduction in GWP potential is achieved with the incorporation of triple-glazed, argon filled windows alone (Table 1). However, the energy savings achieved through the simultaneous incorporation of an additional layer of expanded polystyrene makes this option more cost-effective. When restrictions on other indicators are simultaneously imposed (for example, if the air index of the improvement is not to exceed 1,200) then the optimum result is likely to be different.

Table 1 Comparative Results

Combination	Embodied Energy (MJ)	Solid Waste (kg)	Air Index	Water Index	Annual Operating Energy (MJ)	GWP (tonnes)	Cost ($)
Base Case	92,134	2,006,670	1,119	260,715	221,208	1,244,204	129,815
T Windows	108,482	2,006,909	1,632	260,715	199,723	1,100,164	124,775
Add EPP	94,948	2,006,672	1,186	260,715	215,900	1,208,715	128,602
Both	111,296	2,006,911	1,699	260,715	195,141	1,069,282	123,684

For this example, each of the headings (embodied energy, solid waste, air index and water index) refer to the sum of these factors for the materials used to generate the components discussed. Annual operating energy is used as separate constraint. GWP refers to the sum of the GWP for the materials (from extraction to diposal) and the GWP caused by the use of

eletricity and natural gas for the home as a unit over a 50-year span. The cost refers the sum of in-place construction cost of the materials for each component discussed, the cost of the energy used to operate the home for 50 years, and the cost of demolition and disposal of the components.

Though greatly simplified for effective demonstration of the concept, this example illustrates the potential of the optimization model to be applied more rigorously to investigate trade-offs of far greater complexity. In addition to reductions in global warming potential, the effect of simultaneous reductions in other environmental impacts, such as water pollution, embodied energy of components and solid waste generation may be explored. In fact, it is in the consideration of multiple criteria that the model is expected to prove most valuable.

4. FOUNDATION FOR FUTURE WORK

In the near future, the model will be progressively refined to account for more component options and will thus become capable of investigating additional facets of contemporary trends in sustainable architecture. The rates of deterioration for the various options will be incorporated to probe the effect of scheduled maintenance on the life-cycle cost and life-cycle environmental impacts of the optimum combination of building components. Similarly, the straightforward demolition and disposal of the components at the end of the design life, which is adopted in the example, will be expanded to include recycling options in the analysis. A system of assigning level-of-service equivalence to each of the options put forward for each component will become necessary for more equitable comparisons. Additionally, appropriate discounting factors will be developed to compare the net present value of the optimum selection with the capital cost of the building in order to add more depth to the economic arguments for building greener homes.

These improvements are intended create a more realistic model that would be used as a design tool. Intrinsic in the model is the ability to make inferences, prior to construction, about the conditions under which a particular set of components is considered optimal. Thereby, the user is able clearly discern the areas in which improvements are possible in today's paradigm and areas that are in need of greater innovation in order to push the contemporary boundaries of sustainable architecture. A sensitivity analysis based on several runs of the model will have the greatest potential for developing inferences that will add to debate on the most appropriate way forward for sustainable architecture.

5. CONCLUDING REMARKS

Although the data sources and case study presented have focused on North American residential homes, the method used is certainly applicable to any sustainable building design scenario. With relevant cost and life-cycle inventory data, appropriate sustainability indicators and targets for the particular region, the optimization model can be translated to any corner of the globe for use by homeowners, builders, architects, planners, engineers and government authorities interested in the furtherance of sustainable architecture. This flexibility is a key strength of the model.

The model would be able to account for economic market changes. Any fluctuation in future cost of energy could be easily incorporated. The same is true for cost-based incentives (such as green building tax breaks) and penalties (such as carbon taxes and dumping fees), the effects of which can be reflected in the costs associated with the use of different components.

Another advantage of the optimization approach is that it does not stifle innovation. In fact, the technique is made more powerful through the introduction of new materials and technologies that work towards minimizing environmental impacts at even lower costs to the consumer. As technology evolves and more green strategies become affordable, the indicators and targets can be continuously refined to push the boundaries of common practice. If certain combinations of components are shown to be more environmentally friendly and relatively cost-effective to incorporate, then building guidelines based on these arrangements to be can be integrated into future building codes, through which the potential for effecting change is great.

The primary drawback of the approach is that large quantities of up-to-date life-cycle inventory data on all materials used in construction are needed in order to effectively capture the options available. Additionally, there is a need for software that can realistically capture the environmental impacts of these materials and components working together as a building unit.

However, organizations such as the ATHENA Sustainable Materials Institute and Natural Resources Canada are quickly making significant strides in this area. Thus the potential for optimization to identify an effective balance of costs and environmental impacts in design that ultimately moves the building industry towards increased sustainability is very significant.

6. ACKNOWLEDGEMENTS

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Urban Buildings as Energy Generators

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1. INTRODUCTION

Cities are voracious resource sinks, which require huge hinterlands to support them. These hinterlands are currently coalescing at an alarming rate. We need to find ways of reducing the size of the hinterlands before they start overlapping. The design of many of the current generation of city buildings is patently unsustainable. However, in energy terms, it is conceivable that urban buildings could be designed to be energy generators. The initial goal might be to design urban buildings which would be operationally self sufficient in energy while the mid-term goal would be to achieve life cycle self-sufficiency. The ultimate goal would be to design buildings which would be nett energy generators over their lifespan. In creating such buildings it is not only the building design itself, which is significant, but also its relationship to other buildings, the local infrastructure and its location within the overall city context which ultimately defines a building's energy generating potential.

This paper explores, from both building and contextual design standpoints, a range of strategies which would enhance energy self-sufficiency in urban buildings, by minimising the total energy load of the building, fully utilising passive energy and using energy generating devices in a building powered from readily available, renewable energy sources. A case study building notionally located in Wellington, New Zealand provides focus for the exploration.

Wellington city is the capital of New Zealand. The city itself has a population of around 125,000. The Central Business District serves a greater Wellington area of population close to 500,000. While the main financial and shopping districts have buildings that are mostly 15-20 storeys tall, the case study building is to be placed into the Te Aro area of the CBD which is defined in the Wellington District Plan (WCC) as 'Low Central City' and where building heights are much lower, generally about four or five storeys. The area has building height restrictions which vary from 10.2 metres to 43.8 metres. The area is largely comprised of low-rise industrial or warehouse buildings. Increasingly, many of the old warehouses and the spaces between them are being transformed into apartment buildings. Many buildings are of mixed use. Plot sizes are generally quite small.

The case study building has been defined as being 33mx33m on plan, four storeys high, with abutting buildings of the same height and plan size on its east and west boundaries. The building is assumed to have a mixed use of 50% residential and 50% commercial. The 4 metre floor to floor height of the case study building is deliberately generous to facilitate a

wide range of future changes of use. At present the Wellington City Council (WCC) has no regulations at all regarding daylight, and very few relating to sunlight. Street widths and building spacings are also not defined in city ordnances.

2. MINIMISING ENERGY INPUTS

The goal with the case study building is to develop a design in which both the physical fabric and form contribute optimally to the ideal of minimizing energy inputs, maximizing passive energy generation and optimizing active energy generation throughout its lifespan. A recent study of 35 representative commercial buildings in New Zealand (Property Institute) suggests an average energy consumption of around 972 MJ/sqm, with best figures of around 540 MJ/sqm for commercial buildings. The energy use for heating of an insulated individual house has been estimated (Donn and Thomas) at 207MJ/sqm reducible through good design to 66MJ/sqm. Energy use for space heating is typically one third of the total for the house, so 180MJ/sqm seems attainable, and that is the goal set for this study.

It is important to select materials with low lifecycle embodied energy, if we are attempting to minimize the total life-cycle embodied energy, as we are in this study. This means that not only the initial embodied energy should be low but that the materials selected and the jointing methods employed need to be both durable and low maintenance so that embodied energy remains low during the operation use of the building (Storey 1995). In this case the outer fabric of the building will be designed to last for the lifespan of the building and the interior will be designed to be adaptable to different uses and configurations. If buildings and components are designed for disassembly and reuse or recycling then much of the initial embodied energy can be recovered and the life cycle energy inputs will be further reduced and the life cycle energy balance more easily attained.

The choice of materials is not simple. For example, Treleaven (1993) suggests that, in New Zealand for a building of the size contemplated in this study, with intermittent occupancy, a concrete rather than a timber frame has the best life cycle energy performance. It is assumed that the cladding will be the same for each structural frame, based on choices of energy harvesting “equipment” such as PV cells, solar water and air heating elements and windows for daylight and solar heating, so the major point of difference in life cycle energy analysis is the energy invested in the frame and the effect of the frame on energy efficiency. Over a fifty year period, the benefits from reduced heating and cooling in the higher mass building outweigh the higher energy investment cost of the concrete frame. Energy invested in the concrete shear wall structure would be approximately 9966GJ for a five floor building; and if the building had a timber frame, it would be 5400GJ. Heating and cooling the concrete structure would consume 51052GJ in a 50 year lifetime and the building with the timber structure would need 67953GJ.

All human activities generate heat. Many urban buildings generate more heat internally than they need for human comfort because heat losses through the walls, roof and floor are not enough to dissipate the heat generated. Urban buildings are typically compact in form so they have little surface area through which to lose heat and they abut other buildings and so lose or gain very little heat through these adjacent surfaces. Many urban buildings throw away that heat and often cooling, even in temperate New Zealand, is a bigger energy user than heating. Residential buildings with their much smaller appliance and occupancy intensity require heating for at least half the year in Wellington. The occupancy pattern of the office/commercial areas and the residential buildings is quite different and time shifted. Space use in the case study building is vertically zoned, with the residential element on the sunny

side of the building and the commercial segment located on the sunless side of the structure to take advantage of these factors. The residential areas are warmed by the sun and act a buffer zone for the commercial zones. Energy interchange between the two building uses is possible because of their time shifted occupancy and is facilitated by the sharing of all floors by both residential and commercial uses.

In the case study scenario the façade of both offices and residential accommodation can be highly thermally insulated as excess heat generated in one set of functional spaces can be transferred and used in the other, due to their different and time shifted energy requirements. Surplus energy might be stored as warm water and converted as necessary using heat pumps. Windows would be timber, double-glazed with low-E glass and with inert gas cavity filling. Optimal associated thermal insulation levels would be about R5.0 sqm.^{o}C/W for the roof, and about R3.0 sqm.^{o}C/W for the external walls and ground floor slab.

Urban buildings tend to be built to their site boundaries for their full height. Therefore the case study building is assumed to be of this form. Two 6x10m multi-purpose lightwell spaces are however used to facilitate the provision of adequate natural ventilation and lighting for the full depth of the occupied plan form. The lightwells would be top glazed and centrally located, with opening windows and would also be used for vertical circulation and services. Circulation elements would be designed to be as transparent as possible to minimize excessive shading. Solar control and core daylighting devices will be utilised .

Calculations (Bannister and Guan, 1995) completed for the energy efficiency clause in the New Zealand Building Code, suggest that the HVAC energy use in commercial buildings with average occupancy allowing 22 m^2 per person would amount to 22% of the total energy use in a building. Lighting energy use would amount to 35% of the total. Miscellaneous equipment would be another 35% of the total. The employment of a range of energy efficient technologies will be necessary to achieve the 180MJ per square metre energy target for this building. Energy efficient lighting and control devices, hot water conservation and heat recovery technologies together with energy-efficient appliances will be employed throughout the building. Office equipment will be selected that has built-in power management features that will greatly reduce energy consumption, by switching to low-energy mode when not in use. Energy-efficient motors and transformers will also be necessary.

Daylighting has been proven to be a viable option in terms of energy savings for commercial premises in Wellington. A study by Chan (1978) concluded that, even on the South side of a building, energy cost savings for lighting outweigh the increased cost for extra cooling and for heat lost through the glazing even with standard single glazed windows. It seems likely that in combination with energy efficient lamp technologies and effective lighting controls substantial reductions can be achieved in the work environments in the case study building.

ENERGY GENERATION

Architects wishing to create sustainable buildings take a whole-building approach to design so that all elements of the building help achieve the goal of efficient energy and resource performance. The passive collection of environmental energy flows and the active generation of energy from renewable sources within or in close proximity of buildings are essential parts of this equation. In the next few paragraphs we explore the potential role of the exterior surfaces of the case study building as energy harvesters. New Zealand is blessed with sufficient sun and wind that it seems likely that in the not too distant future it will be possible to generate all required building energy needs from these two sources, provided that design

and building professionals reduce the energy consumption potential of buildings in the manner outlined above.

This paper looks in particular at the likely return from technologies such as Solar Hot Water and Space Heating and Cooling whether through Preconditioning of Intake Air through In-Ground Pipes or Ducts or Heat Recovery or Exchange Systems. It also examines the potential contribution of Photovoltaic Electricity (PV) and Small-Scale Wind Turbines. Geothermal, micro-hydro and Hydrogen Fuel Cell approaches might well be added to this basic energy supply in other cities where cost and availability of the energy source were appropriate.

Passive and active solar thermal and electric energy systems such as hot water collectors and photovoltaic (PV) cells can be effectively integrated into roof or wall surfaces of buildings, especially for residential and small commercial applications. In Wellington, New Zealand, the average yearly solar radiation falling on the roof of a 1000 square metre building would be 4,531GJ. With the two atria penetrations in the roof, the nett area for placing PV arrays or solar thermal collectors is 880 square metres. This is equivalent to 629 GJ per month in summer and 158 GJ per month in winter. The atria do not waste the energy harvest opportunity. Rather they allow the opportunity to collect and deliver solar heat and light where and when appropriate into the heart of the building. A traditional east west saw tooth roof might well have its north facing surfaces covered in PV and solar water heating elements and its South Facing vertical surfaces capturing daylight.

For a north facing wall, 20 m tall (assuming the building is 5 storeys high) and 33 m wide, the maximum potential solar radiation is approximately 259GJ per month when the sun is high in the sky in summer and 308GJ per month when the sun is low in the sky in winter. Windows are seen as taking up no more than 50 % of the area of the north facing wall. This would ensure that the optimum energy balance is maintained for the building, with areas on other walls being larger in order to provide adequate diffuse daylighting. This would leave the other 50% of the north facing façade of the building available for a mix of passive and active solar energy harvesting. This could be in the form of glazed ducts backed by highly insulated walls would be used as energy generators by passing the sun warmed air through a heat recovery system located at the top of the wall.

The average annual electrical energy available from the wind using a 20m diameter wind turbine in Wellington is around 22,000MJ split evenly out over the months. It might be possible at most to place two of these on the roof of the 1000 square metre building without the blades interfering too much with each other.

The average rainfall 1231mm of rain in Wellington would amount to 1231 cubic metres of water landing on the roof per year – a potential energy supply of 241 MJ if all the energy in the water flow could be retrieved were the water allowed to drop through an electricity turbine from a height of 20m.

Each of these potential energy sources has a benefit and a cost. Some of the costs are obvious: the disturbing vibration of a wind turbine; or the cleaning and maintenance of a PV array on the roof converting solar energy into electricity. Other costs are equally as important in assessing sustainability: guaranteeing rights to light for PV energy generation or rights to exposure to certain high winds for wind turbines. Solar thermal collection systems for hot water and space heating require efficient storage systems in the mass of the building or in liquid storage tanks. Designers need to carefully assess materials and placement of storage

systems to achieve optimum results. In this case study building, there could be a conflict between the need for solar electrical energy generation and the need for solar heated water. Solutions such as water cooling the PV cells will be necessary.

Photovoltaic cells can currently operate at about 20% efficiency and experimental units achieve efficiencies of 25%. Therefore in Wellington, the flat rooftop can supply at best 0.25*4,531,900 or 1,133 GJ of PV generated electrical energy per year. The energy needed for the five floors of office space at the proposed level of energy efficiency in buildings would be 5 * 880 * 180 MJ per year or 792 GJ per year. Translucent and coloured PV arrays are being used in a variety of buildings. Translucent arrays can be used to integrate daylighting and shading devices while at the same time collecting electrical energy. The energy return may therefore be as high as 50% of the available sunshine.

Battery technology for storing electrical energy is often a stumbling block, but progress is being made to develop less toxic and longer-lasting battery designs. In some buildings, PV cells have been used to convert water into hydrogen gas that can be stored in tanks and converted into electricity or heat energy via fuel cells when needed. The use of hydrogen as a fuel and energy carrier will require an infrastructure for safe and cost-effective hydrogen transport and storage. In New Zealand, with approximately 75% of the electrical energy supply being generated by hydro power, it makes most sense to "store" surplus electricity in the national grid – effectively using the hydro-electric dams as "batteries".

URBAN FORM

High ambient wind speeds are experienced on a regular basis in Wellington. At least one CBD building has caused wind problems at ground level for pedestrians since the 1920's. Police were stationed on these windy corners in the 1920's and 30's to assist people across the street. And, well into the 1960's, ropes were placed at particularly windy corners to prevent people from being thrown inadvertently in front of passing traffic.

A Wind Ordinance (WCC) was introduced in Wellington approximately 20 years ago. A survey (Davies) of the role of the wind tunnel in building environmental design has shown wind tunnel simulation of reality contributes greatly to the improved quality of urban life. On the basis of this success, the CBPR has suggested that the City could set up performance criteria for all desirable environmental qualities. It is argued that the conventional tools for achieving environmental qualities like solar access, such as height or other dimensional limits, are crude and ineffective tools in a complex urban environment. One might even create an index of outdoor comfort that accounted for combinations of wind, sun and temperature.

Work is proceeding in Wellington on the development of such an index using a CAD model and wind tunnel tests. People's preferences in terms of combinations of sun, wind and air temperature are being assessed and will be combined in an index of habitability. In the context of this paper, this analysis will be extended further: one needs to know how much sun is striking the roofs and exposed walls of the buildings, and how much wind is available for electricity generation above the buildings. The goals of quality street environments (calm, warm, sunny) may at times be inconsistent with the goals of energy generation in a building (high levels of sun and light on the walls and roofs, high wind speeds above the building).

The area of Wellington under consideration for this case study building is made up of a very few blocks, with some sites having dimensions of 75 metres by 34 metres. To ensure any sort of daylighting levels for these sites, new streets or daylight corridors would need to be

provided. The key issue to arise out of this analysis of the energy harvesting potential of central Wellington buildings is that, even in this city known for its wind, the most significant potential energy source is the sun. Solar energy can be guaranteed on the roof only if building height limits are enforced. If height limits are removed in favour of a performance index approach, then the planning would also need to include stringent solar access requirements.

Guaranteeing solar access for the north façade is the difficult issue. The street width must be 42m to guarantee sunshine on the whole of the north façade at mid-winter in Wellington, if the building across the road is the same 20m height as the case study building! To shade the building by only 50% at the minimum then the street width would need to be 21m. Typical street widths in the neighbourhood are currently 12m. This means only 25% of the north façade receives full sun at mid-winter.

CONCLUSIONS

The 180MJ per square metre energy use target in the case study urban building requires improving energy efficiency to one fifth of the current average energy use in office buildings. At this rate, the total annual energy requirement of our case study building would be 820GJ. To achieve this level will require more than just improved insulation, it will require an holistic analysis of all energy uses in the building. The total amount of solar radiation on the north wall and roof in summer is 888GJ per month. This falls to 466GJ per month in winter if the building is unshaded and 235GJ with streets the width of the existing streets. Even at low PV efficiencies of 20% there is huge potential in the direct solar energy to make the building at a minimum self sufficient, if not a nett generator of energy. However it requires that the whole system of urban design alters not only to facilitate design of such a building through careful design of street widths and definition of solar rights, but also to guarantee lifetime access to solar energy.

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Recycling technology in the clay brick industry

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1. INTRODUCTION

The stony fraction of Construction and Demolition Waste (CDW) is about 12 million tons on yearly base. This amount was almost totally reused for the production of road construction granulate. Enough for a six lane highway over 340 km, which is from Maastricht to Groningen, each year. It is not in the governmental policy to solve the traffic problem by constructing more roads. This results in less road building projects in the next few years. Therefore the demand for granulate as a road construction material will decrease, because the market for road building materials will be saturated. Other ways of reuse or recycling should be developed to make a sustainable future of the total building sector possible.

Not only the policy makers are responsible for the sustainable use of building materials, but the whole building cycle is. An integral approach from the initial phase until the demolition stage is necessary to make a real change in the building sector. The policy makers, the architect, the builder, the user and the demolition contractor all have there responsibilities. In an early phase of the development of building projects the final demolition stage should already be included. This makes it easier to dismantle the construction and to separate the material streams on site. An integral approach leads to a reduction of construction waste, a reduction of the extraction of raw materials and finally to a reduction of costs.

Nevertheless issues that are generally accepted in other branches of industry, are still not in use in the building sector. In the car branch for example the producer is responsible until the demolition stage. The car is being assembled in a way that it can easily be disassembled. In the building sector the responsibility of the contractor or supplier of building materials takes until completion of the project. But also in the demolition stage there are responsibilities.

The amount of CDW has slightly be increased since 1990. The biggest part is from the commercial and industrial buildings and civil constructions. The waste stream mainly consist of demolition debris. Besides that there is a big part of fraise asphalt that is being released during renovation of road pavement. In order not to use scare land space as landfills, the government has decided to introduce the dumping decree. Two reasons formed the cornerstone of this governmental policy, namely the reduction of CDW and the stimulation of reuse and recycling of waste materials. Since 1995 the amount of CDW that was landfilled stabilized at approximately one million tons yearly. Since 2000 a landfill ban is introduced for CDW that

Table 1 Amount and treatment of Construction and Demolition Waste (CDW), 1985-2000

	1985	1990	1995	1997	1998	1999	2000
	million tons						
Total	12	13	14	16	17	18	19
Reused	6,1	9,3	12,8	14,9	15,8	16,6	18
Combusted	0,10	0,15	0,15	0,23	0,23	0,2	0,2
Landfill	6,1	3,2	1,0	1,0	1,0	1,2	0,8

Source: RIVM; WAR.
RIVM/MC2001

is combustible or reusable. The reuse of CDW has been increased quickly and the amount that was landfilled decreased. Also the rise of the dumping fee was a reason for the reduction of landfilling. More and more CDW has been delivered at sorting plants. In the year 2000 the total amount of CDW was approximately 19 million tons of which 18 million tons was reused, 0,2 million tons combusted and 0,8 million tons went to the landfill (table 1). About seventy percent is stony waste, both concrete and masonry debris that is being processed as road construction granulate.
The figures look impressive, but a further consideration learns that it is not an optimal situation and not a bearable situation. Alternatives should be introduced to process the enormous waste stream in a sustainable and durable way, because a slight change in the road constructing industry can lead to problems.

2. DELFT LADDER

An instrument is necessary to make decisions between sustainable alternatives. A support system is developed by the Civil Engineering Material Science Department of the Technical University of Delft. The Delft ladder is based on the ladder publicized by Lansink in the beginning of the eighties. The Delft ladder is a decision support system for sustainable alternatives. The following alternatives are included, ordered on sustainability:

1 prevention
2 reuse of entire construction
3 reuse of elements
4 material reuse/recycling
5 useful application
6 immobilization with useful application
7 immobilization without useful application
8 combustion with energy recovery
9 combustion
10 landfill

The Delft ladder is a support system for making policy decisions that must flexible be interpreted. An alternative higher on the ladder is not always a better alternative from sustainable point of view. Also the environmental effect must be taken into consideration. An alternative higher on the ladder can cause an environmental load, which makes it from sustainable point of view a worse alternative.

There are two arguments for introducing alternative applications for the stony fraction of CDW. The dependence of the demolition branch on the road construction branch and the limited

admission capacity of it. A second argument is the aspiration for a high-quality application from sustainable point of view. The government has declared that the extraction of minerals is limited (marl and gravel). There is a strong impulse from the concrete production branch to use concrete granulate as an aggregate for concrete production. The market for mixed granulate comes under pressure, because the road construction granulates should at least contain sixty percent of concrete granulate. For masonry granulate there are no other applications available, therefore it is necessary to introduce alternatives. Not only because of the situation concerning CDW, but also for the image of the clay brick industry.

For the recycling of masonry debris it can be preferred that separation takes place at the source. When masonry is dismantled separately on site, it can be prevented that damage occur to the clay bricks. For the recycling of masonry a recycling schedule is made (figure 1). The thermal treatment is the core of the recycling schedule. Clay bricks are recovered from masonry debris by a thermal treatment. In this process three streams are separated, namely the whole clay bricks, the mortar and the broken clay brick pieces. Research is done by performing laboratory experiments and this resulted in a pilot project in the factory of Terca in Reuver. The thermal process makes it possible to recover approximately 50% of the clay bricks. The demolition process however is of vital importance to reach a high recovery. The rest fraction consists of broken clay brick parts and slices of mortar and can be separated by using physical and mechanical separation methods, for example electromagnetic separation. The broken clay brick part can be crushed and reused as raw material for clay brick production. On laboratory scale the clay brick production from granulate proved to be successful. The mortar fraction might be reused for concrete or mortar production. The cement is partly dehydrated in the thermal process. A calcium hydrate or carbonate loses the chemical bound water between 300°C and 400°C. A further research on the applicability of the mortar is required for concrete or mortar production.

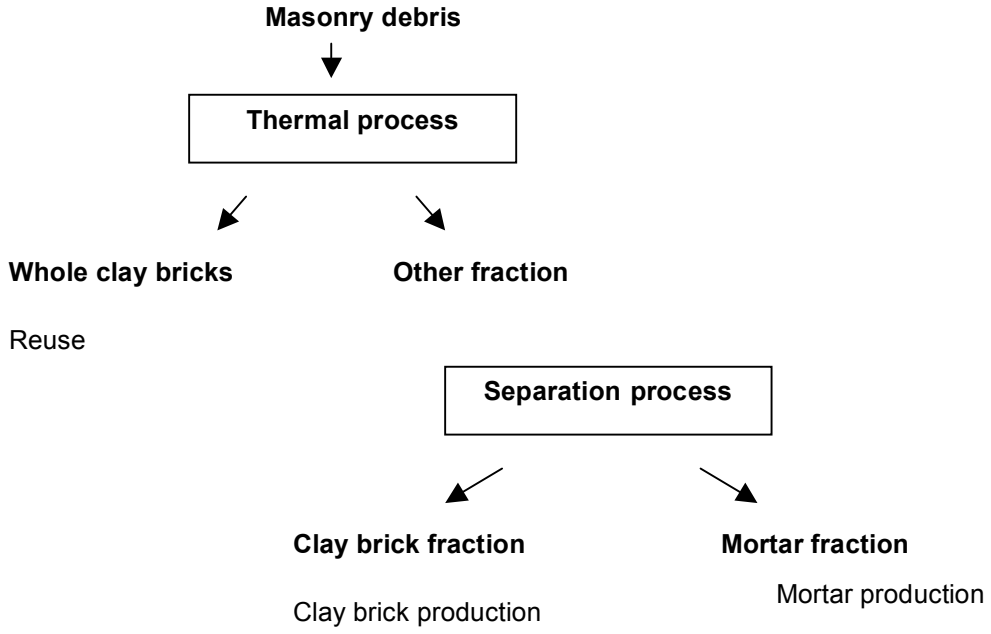

Figure 1 Recycling schedule for masonry debris

3. RECOVERY OF CLAY BRICKS FROM MASONRY DEBRIS

The aim of the research in the first pilot was to recover clay bricks from masonry debris and the verification of the laboratory experiments on practical scale. From the laboratory research was concluded that the most optimal temperature for clay brick recovery is 540°C. This temperature is lower than the conversion of quartz temperature (573°C), but introduces enough strains for most masonry types to break the mortar clay brick interface. For the experiments masonry pieces from a demolition site were transported to the factory and stacked on the oven wagons. Two oven wagons were placed in the periodic chamber kiln, which was used for this test. The temperature was increased in ten hours up to 540°C, followed by a stabilizing period of ten hours. Then the oven was slowly cooled down.

The difference in thermal expansion coefficient between the mortar and clay brick gives strains on the clay brick mortar interface. This interface zone breaks, when a certain temperature is reached. In fact the temperature can be cooled down immediately after that. Not too quick because temperature differences in de product give strains. The percentage of clay bricks that can be recovered depends the feasibility in practice.

4. MAKING A MODEL

The situation of strains caused by thermal loads was modeled as a composite material, consisting of a layer of mortar and a layer of clay brick. The difference in expansion coefficient between clay brick and mortar introduces tensile and compressive stresses when thermally loaded. At the clay brick mortar interface a shear stress is introduced (figure 2).

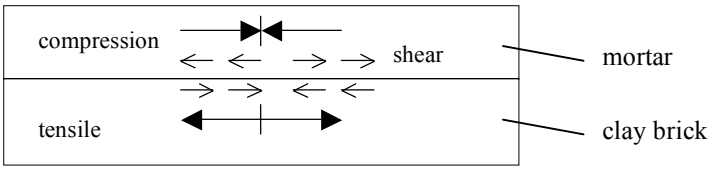

Figure 2 Strains in the clay brick mortar interface caused by a temperature load

Now the boundary conditions for this loading situation were made up. The total expansion (formula 1) of a material is the sum of thermal expansion and expansion caused by strains (formula 1). The tensile or compressive load can be written as a function of expansion. The strain (formula 2) is the first derivative of the change in length in a certain direction.

$$\varepsilon = \alpha T + \frac{N}{EA} \qquad (1)$$

$$\varepsilon = \frac{\partial u}{\partial x} \qquad (2)$$

This results in an equilibrium with a main force, which is a function of the strain (ε) and the thermal expansion coefficient (α). The shear stress (q) is the first derivative of the main force in the x direction (formula 3).

$$q = -\frac{\partial N}{\partial x} \qquad (3)$$



Figure 3 Material model of the clay brick and mortar interface

In figure 3 the material model of clay brick mortar interfacial zone is shown. Both layers have a Youngs modulus, surface area and thermal expansion coefficient. The effective thickness of the mortar layer is 4 mm and for the clay brick it is 25 mm.
Until the clay brick mortar interface is broken, there is an internal equilibrium. The compression force in the mortar layer is equal to the tensile force in the clay brick. The expansion for both materials is equal. For this loading situation a parallel system is valid, which means that the stiffness of both materials must be summed. Using formula 1 together with the second boundary conditions results in formula 4.
The boundary conditions are:

$$N_I + N_{II} = 0$$
$$\varepsilon_1 = \varepsilon_2 = \varepsilon \qquad \frac{N_1}{EA_1} + \alpha_1 T = \frac{N_2}{EA_2} + \alpha_2 T \qquad (4)$$
$$EA = EA_1 + EA_2$$

The solution is found by using boundary condition 1 and 3 with formula 4.

$$N_1 = -N_2 = \frac{EA_1 \cdot EA_2}{EA}\left(\alpha_2 - \alpha_1\right)\cdot T \qquad \text{and} \qquad \varepsilon = \frac{EA_1\alpha_1 + EA_2\alpha_2}{EA}\cdot T$$

Resulting in a total thermal expansion coefficient: $\alpha = \frac{EA_1\alpha_1 + EA_2\alpha_2}{EA}$

The shear stress (q) is the first derivative of the main force in the x direction (figure 4).

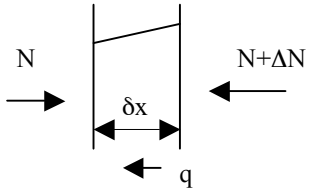

Figure 4 The shear stress is the first derivative of the main force N

The force N is independent on x, because formula 1 is valid on the whole clay brick mortar interface. Therefore the shear stress on the clay-brick mortar interface must be constant. From literature values can be found for the thermal expansion coefficient and Youngs modulus both for clay bricks and mortar.

Clay brick: $\alpha_1 = 3 - 9\cdot 10^{-6}\,K^{-1}$ and $E_1 = 10 - 20\cdot 10^{9}\,Pa$

Mortar: $\alpha_2 = 10 - 12\cdot 10^{-6}\,K^{-1}$ and $E_2 = 20 - 40\cdot 10^{9}\,Pa$

The huge variation in values for different clay bricks and mortars results in a big range in shearing stress at certain temperatures. For example, when the temperature is 540°C then the shearing stress ranges between 0,35 and 5,60 N/mm^2 for the extreme values of the thermal expansion coefficient and the Youngs modulus.

Table 2 Load on the oven wagons

Oven wagon 1

	Thickness masonry piece	Color clay brick	Type of mortar	Detail
a1	1 brick	Bronze	Lime	
a2	1 brick	Bronze	Portland cement mortar (PC)	
a3	1 brick	Red	PC	
a4	1 brick	Yellow	Lime	
b1	1 brick	Red	Lime	
b2	1 brick	Yellow	PC	Plastered
b3	1.5 brick	Red	Lime	
c1	1.5 brick	Red	PC	
c2	1.5 brick	Red	Lime	
c3	1 brick	Yellow	PC	
d1	1.5 brick	Red	Lime	
d2	1.5 brick	Red	PC	
d3	1.5 brick	Red	PC	

Oven wagon 2

	Thickness masonry piece	Color clay brick	Type of mortar	Detail
a1	1.5 brick	Red	lime	
a2	1 brick	Red	PC	Plastered
a3	1.5 brick	Red	Lime	
b1	1 brick	Yellow	PC	Plastered
b2	1 brick	Red	Lime	Plastered
b3	1 brick	Red	PC	
c1	1.5 brick	Red	Lime	
c2	1 brick	Dark red	Lime	
c3	1 brick	Yellow	PC	
d2	1.5 brick	Yellow	Lime	Small format hard clay bricks
d3	1.5 brick	Red	PC	

5. TRANSLATION TO PRACTICE

The pieces of masonry were collected on the processing site of the company Bottelier in Haarlem. On the site the stony debris is crushed in order to produce road construction granulate. The masonry mainly
consists of 1½ stone masonry. Only that type of masonry was not totally damaged after demolishing and transport. Six tons of masonry was transported to the Terca factory in Reuver.

The masonry contained different types, with red and yellow clay bricks, lime mortar and Portland cement mortar, with and without a plaster layer. In the factory the pieces of masonry were stacked on the oven wagons. Heat resisting blocks were used to create an open stack in which the heat can easily divide. The stack had a height of four pieces of masonry and the total load per oven wagon was 3 tons. Table 2 shows the load on the oven wagons.
The two oven wagons were placed in the chamber kiln and per wagon two thermocouples were installed in order to measure the temperature development in the stack. One thermocouple was placed in the stack, while the other was placed on the stack. The temperature treatment consisted a heating period of ten hours and a stabilizing period of twenty hours at 540°C. Then the oven was cooled down slowly by shutting down the gas flow. This should result in enough fracture planes to make clay brick recovery possible.

6. TEMPERATURE TREATMENT

At a certain moment during heating the gas pressure was increasing too much, this resulted in a higher temperature than 540°C. In some spots in the kiln a temperature of 800°C was measured. The sudden heating and high temperature caused damage to the clay bricks. Cracks were initiated in the clay bricks when suddenly the quartz conversion took place at 573°C. During cooling the stack collapsed and the clay bricks fell on the burners.

7. RESULT

The masonry came from a processing plant for road construction granulate. During demolishing and transport most of the half brick masonry were broken. Therefore only masonry pieces with a thickness of at least one brick were used in the experiment. In the future situation however, the masonry should be taken separately and transported directly to the factory. Then a big part half brick masonry can be included. For half brick masonry the clay brick mortar interface area is smaller and separation easier. The clay bricks from half brick masonry are esthetically of better quality, because the sides of the brick were not in contact with mortar.

Because of the sudden heating in the kiln as a result of the uncontrollable gas flow, the temperature was too high. The heating and cooling rate were too high and therefore a big part of the clay bricks were broken. For most clay bricks the plane of fracture was exactly in the middle of the brick.
For the 1½ brick thick masonry the outside bricks were broken, while the internal bricks were unharmed. This is a result of the less radical temperature treatment of the internal bricks. The clay bricks that were in direct contact with the heated air were almost all broken. The internal clay bricks were recovered easily and had a gray appearance. Esthetically they were of less quality.
The separation for PC mortar was easier than for lime mortar, because the clay bricks had a layer of lime mortar on the surface, while the clay bricks with PC mortar were totally clean. The soft red clay bricks in combination with PC mortar showed a lot of cracks. The harder clay bricks in combination with PC mortar resulted in a higher recovery rate.
About ten percent input mass of the clay bricks were recovered. This low percentage was a result of the incorrect temperature treatment and the high temperature that was reached. The selection of whole clay bricks from the stack happened by hand, this was a labor intensive job and took a lot of time. No mechanical force was necessary to remove the mortar from the clay bricks. In a practical application of the process this part can be automated. With the use of a vibration screen

the mortar layers can be separated from the clay brick. Such clay brick sorting machines are in use in the road construction sector.

As an optimization step a further experiment was performed in which a building was selective dismantled and the masonry directly transported to the factory. The railway building on shunting-yard ‘de Boezembocht’ in Rotterdam was built in the1970’s. The exterior walls were made of yellow clay bricks in combination with PC mortar, while the inside wall consisted of limestone. The cavity was filled with rock wool.

The interior and exterior walls were connected by anchors. This made difficult to remove big pieces of masonry at once. Often a piece broke, but in total 2,5 tons of masonry was collected. The masonry was transported to the factory and stacked on the oven wagons. The temperature treatment was the same as the earlier one, but this time correctly performed. Ten hours heating and twenty hours stabilizing at 540°C and then cooled down in ten hours. The oven wagons contained less masonry then the first time to prevent collapsing of the stack during the temperature treatment. After the temperature treatment was finished, the oven wagons were removed from the chamber kiln and the clay bricks were sorted. The result was:

- 900 kg whole clay bricks
- 900 kg broken clay bricks (half)
- 220 kg damaged clay bricks
- 505 kg mortar
- and some steel anchors

The recovery in this case was 45% of the incoming amount of clay brick. Which is a very good result, but it strongly depends on the demolition process. In this case with relatively rough equipment. The recovery can be much higher when care is taken during demolition.

8. CONCLUSIONS AND RECOMMENDATIONS

The feasibility of clay brick recycling with regard to clay brick recovery depends on the demolition process. The demolish contractors are obliged to separate the materials carefully. For a simple demolition project like the railway building from which the masonry came, nine material streams were separated. The advantage is that pure material streams can be recycled or reused easily. The material streams from this building were; steel, different categories of wood, bitumen, rock wool, glass, stony debris, combustible waste etc.

The demolition equipment that was used in this project was probably too big for careful deconstruction. The anchors in the cavity wall made the selective dismantling more difficult. Nevertheless a recovery of about 45% was achieved of the input clay bricks mass. This looks successful, but for practice the process must be automated. The demolition contractor was enthusiastic about selective dismantling, because it did not take more time and resulted in less costs for disposal.

Environmental evaluation of Thermal Inertia factors of Building Envelopes as a function of Solar Absorptivity

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1. INTRODUCTION

Solar energy affects significantly the energy requirements and the indoor environment of buildings. Its utilization is important as it provides a suitable and sustainable environment for indoors without having a negative impact on the environment. The interaction between construction and environment is pointed out by Howes et al. (1998). The exploitation of solar energy which began at the very early periods when ancient Greeks and Romans implemented passive solar systems in their buildings, is a complicated and multifaceted procedure in view of the fact that radiant energy is intermittent in occurrence and is diffuse in intensity. Thermal processes involving conduction, convection and radiation enable building materials to store energy. Thus, a fraction of the incident solar flux can be collected and stored in the thermal mass of the building envelope allowing part of the required energy demands to be covered; the stored heat is progressively released and a steadier overall environment can be obtained.

The fraction of irradiation absorbed by a surface is called absorptivity or outdoor absorption coefficient and is important since it allows the determination of the temperature profiles at the outer surface of the wall. As the exterior colour of the opaque wall is getting darker the outdoor wall temperatures are increasing. These temperatures are derived by the sol-air concept and specify the exterior diurnal forcing function that affects the indoor environment. The time ($t_{Ti,max}$ - $t_{Te,max}$) it takes for the heat wave, with a period P, to propagate through the wall is defined as time lag or phase lag, φ; the decreasing ratio of its temperature amplitude is defined as decrement factor, f. The above thermal inertia parameters are shown in Figure 1, for the case of a sinusoidal heat wave propagating from the exterior to the interior of a wall. Their evaluation for buildings is vital to maintain a comfortable indoor environment, with small temperature fluctuations and low energy demands.

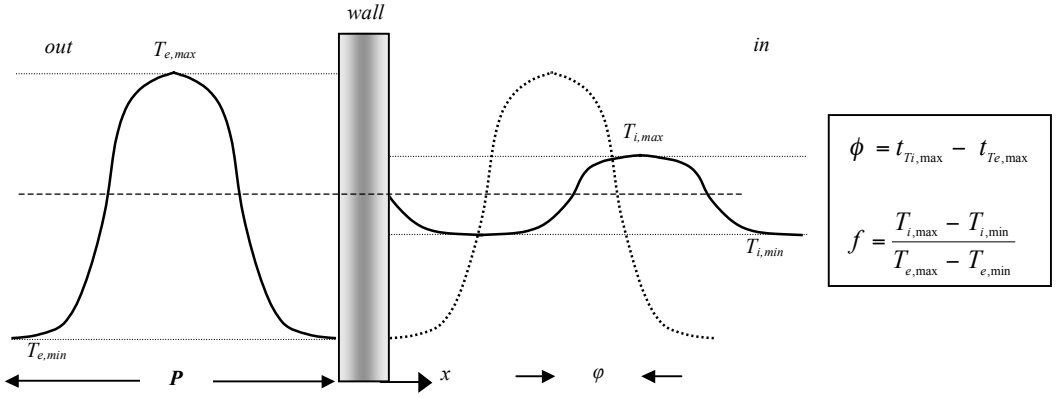


Figure 1 Schematic representation of heat wave propagation through a wall.

A number of studies deal with the impact of the thermal mass and the selection of appropriate insulation, including the thermophysical properties of the materials involved and their position, on the building thermal inertia factors. Asan et al. (1998), Asan (1998) and Asan (2000) investigated the above by employing the Crank-Nicolson scheme. In another study Ulgen (2002) has examined experimentally the thermal behaviour of various wall formations under the effect of solar radiation and his results were compared with theory.

In this study, the main objective is to determine the impact of outdoor absorption coefficient on time lag, decrement factor and temperature swing in the inner surface for different wall formations. A thermal-network model is employed in which distributed thermal resistances and capacitances are connected to each other via a number of nodes. The investigation is carried out for an insulated brick-wall (six wall formations) with south orientation, during summer in the Mediterranean region.

2. HEAT TRANSFER AND THERMAL-NETWORK MODEL

A one-dimensional heat wave propagation is assumed from side to side of a wall in the x direction, in the time domain. For a homogeneous wall of thickness dx the heat flow rate in the x direction of decreasing temperatures is expressed by the well-known Fourier's law:

$$k \cdot \frac{\partial^2 T}{\partial x^2} = \rho \cdot C_p \cdot \frac{\partial T}{\partial t} \tag{1}$$

where k is the thermal conductivity, ρ is the density and C_p is the specific heat of the material. In order to solve this problem two boundary conditions and an initial condition are required. The boundary conditions on both sides of the wall, based on Newton's law, are:

$$\frac{\partial T}{\partial x} = \frac{h_e}{k} \cdot (T_{sa} - T_{x=0}) \qquad \frac{\partial T}{\partial x} = \frac{h_i}{k} \cdot (T_{x=\Sigma di} - T_{in}) \tag{2}$$

where h_e and h_i are the heat transfer coefficients in the outer and the inner wall surfaces. The temperatures $T_{x=0}$ and $T_{x=\Sigma di}$ correspond to the outer and inner surfaces respectively, while T_{sa} is the sol-air temperature and T_{in} is the room air temperature. The steady-state solution at $t = 0$ is considered as the initial condition.

2.1. Thermal-network model

The schematic of the thermal-network model, which is used in this study, is shown in Figure 2. The thermal circuit is derived by the analogies between the thermal and electrical laws; consequently, node voltages and branch currents correspond to temperatures and heat flows, respectively. A computer program, based on the nodal approach, was developed to assess the dynamic behaviour of the circuit in discrete time steps. A brief description of the mathematical formulation and the solution procedure has been presented in another study by the present authors (2002).

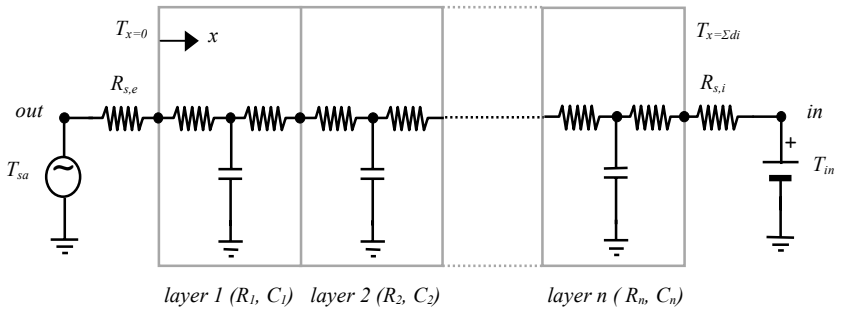


Figure 2 One-dimensional thermal-network model used in the transient analysis.

The present modelling of the wall formation employs a network with several distributed thermal resistances and capacitances. Lombard and Mathews (1999) in their study refer to the layer representation of lumped models. Each section layer comprises two resistances R_i and a single lumped capacitance C_i at the mid-node; the number of sections must be large enough to ensure a good accuracy. The values of the elements in the *RC*-sections are determined on the basis of the thermophysical properties and geometry of the materials involved:

$$R_i = \frac{d_i}{k_i \cdot A} \qquad C_i = \rho_i \cdot C_{p,i} \cdot d_i \cdot A \tag{3}$$

where A and d_i correspond to the layer area and thickness, respectively. The *RC*-sections comprising the wall layers are connected to the exterior and the interior environment with heat transfer resistances. The heat transfer coefficient values (outside for $R_{s,e}$ and inside for $R_{s,i}$)which were considered are h_e = 16.67 W/m^{2}K and h_i = 8.33 W/m^{2}K, respectively.

2.2. Environmental settings

In order to determine the impact of the outdoor absorption coefficient a_s on thermal inertia parameters, the investigation is performed for a wall with south orientation during the cooling season. The outside environmental data of the model correspond to the mild Mediterranean climate and for a latitude 40° N. The ambient-air T_o and sol-air T_{sa} forcing functions, modelled with voltage sources, are given by the following equations:

$$T_o(t) = T_{o,mean} + \frac{\left| T_{o,\max} - T_{o,\min} \right|}{2} \cdot \sin(\omega \cdot t - \frac{\pi}{2}) \tag{4}$$

$$T_{sa}(t) = T_o(t) + \frac{a_s \cdot Q_{sol}(t)}{h_e} \tag{5}$$

where $T_{o,min}$, $T_{o,max}$ and $T_{o,mean}$ correspond to the minimum, maximum and mean outdoor temperatures during a day period (24-h). The rotational velocity is $\omega = 2\pi f$, with a radial frequency f = 1 / 86400 s. The ambient-air temperatures are assumed to have a sinusoidal variation, during a day period (approximating fairly well the exact meteorological data) and range within 22 ^{o}C to 30 ^{o}C. The sol-air temperatures, that includes the effect of solar radiation on outdoor temperatures, depends on solar absorptivity which is varied from 0 to 1. Cengel (1998) provides the solar incident radiation variations Q_{sol} for average days with no clouds and for summer. The maximum outdoor temperature appears at 3:00 a.m. and the sol-air temperature reaches its peak value earlier, since the incident solar radiation is maximum at 12:00 p.m.. As solar absorptivity is increasing the peak value of the sol-air temperature appears earlier.

3. RESULTS

The investigation was carried out for a masonry wall (M: brick with thickness d = 18 cm), having insulation (I: d = 4 cm as one layer, or d = 2 cm as two layers) and coatings in the exterior and interior surfaces (C: d = 2 cm at each surface). Consequently, the total thickness of the wall formation is 26 cm. The thermophysical properties k, ρ and C_p of the materials in the wall formations, are given in Table 1.

Table 1 Thermophysical properties of the materials in the wall formations.

No	Material	k [W/K m]	ρ [kg/m^3]	C_p [J/kg K]
1	Masonry	0.52	1200	800
2	Insulation	0.04	16	1200

3	Coating	0.87	1900	1000

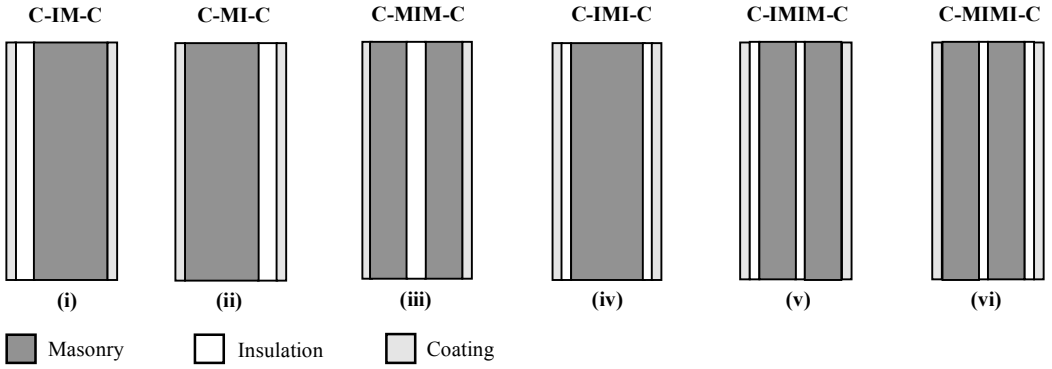


Figure 3 Representation of wall formations: (i) IM, (ii) MI, (iii) MIM, (iv) IMI, (v) IMIM and (vi) MIMI.

Figure 3 (i)-(vi) shows the different wall formations (six configurations), which are investigated in this work. In the following, time lag, decrement factor and indoor temperature swing are determined as a function of solar absorptivity.

3.1. Time lag

Computer results concerning the effect of solar absorptivity a_s on time lag φ are illustrated in Figure 4 (a)-(b); these are obtained with the insulation as a whole and as two layers. For all wall formations, as solar absorptivity increases from 0 to 0.2, time lag is also increasing; a further increase up to 1, causes time lag to decrease. As a result, the optimum solar absorptivity, resulting to the maximum time lag, is 0.2. It can be seen that the minimum time lag corresponds to a_s = 1. For the one-layer insulation time lag is maximum when the insulation is placed in the mid-center plane of the wall (MIM). For the other two formations (IM and MI) the time lag is lower. For a_s = 0.2 it is φ_{MIM} = 8.56 h, φ_{IM} = 8.53 h and φ_{MI} = 8.39 h. For the two-layer insulation time lag is maximum when one layer is placed on the outer surface and the other in the mid-center plane of the wall (IMIM). For the remaining two formations (MIMI and IMI) the time lag is lower. Hence, for a_s = 0.2, it is φ_{IMIM} = 10.36 h, φ_{MIMI} = 10.08 h and φ_{IMI} = 9.76 h. Thus, the placement of the insulation as two separate layers improves considerably the time lag.

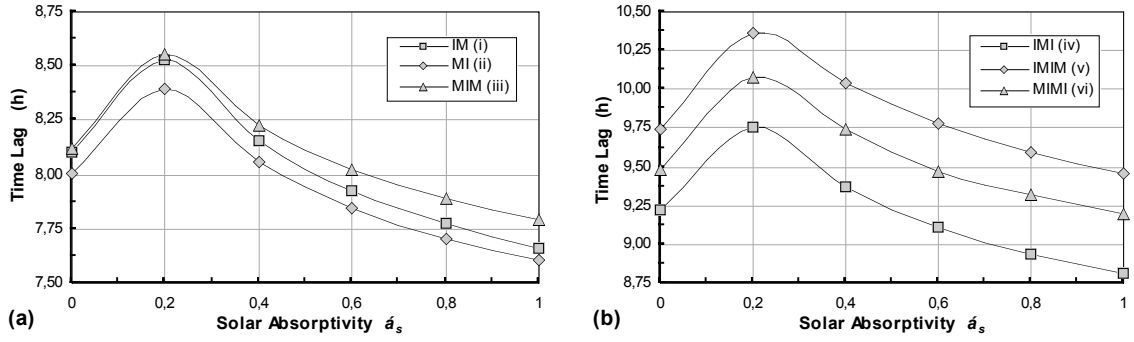
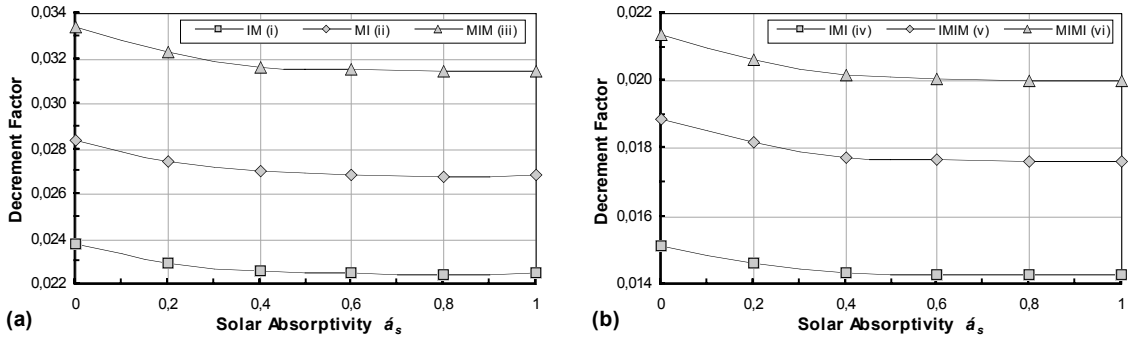


Figure 4 Time lag vs. solar absorptivity for six wall formations with insulation as: (a) one layer and (b) two layers.

3.2. Decrement factor

As shown in Figure 5 (a)-(b), solar absorptivity a_s has a profound effect on decrement factor *f*. The placement of insulation also affects this factor. For all wall formations, the decrement factor decreases, approaching a constant value, as solar absorptivity increases from 0 to 1. As

a result, the minimum decrement factor occurs for $a_s = 1$. The maximum decrement factor appears for $a_s = 0$. In Figure 5 (a) the decrement factor is minimum when the insulation is placed on the outer surface of the wall (IM). For the other two formations (MI and MIM) the decrement factor is higher. For $a_s = 1$ it is $f_{IM} = 0.0225$, $f_{MI} = 0.0268$ and $f_{MIM} = 0.0314$. As shown in Figure 5 (b) the decrement factor is minimum when half of the insulation is on the outer surface of the wall and the other on the inner surface (IMI). For the remaining two formations (IMIM and MIMI) the decrement factor is higher. Hence, for $a_s = 1$, it is $f_{IMI} = 0.0143$, $f_{IMIM} = 0.0176$ and $f_{MIMI} = 0.0200$. The placement of the insulation as two separate



layers reduces significantly the decrement factor.

Figure 5 Decrement factor vs. solar absorptivity for six wall formations with insulation as: (a) one layer and (b) two layers.

3.3. Indoor temperature swing

The difference between the minimum and maximum temperature in the inner surface of the wall, during a day, defines the indoor temperature swing and affects the comfort level of the interior environment. The temperature swing *sw* in the inner surface of the wall as a function of solar absorptivity a_s is illustrated in Figure 6 (a)-(b). The graphs correspond to wall formations having the insulation in one or two layers. For all wall formations, as solar absorptivity increases the temperature swing also increases while the decrement factor decreases. The minimum and maximum temperature swings correspond to $a_s = 0$ and $a_s = 1$, respectively. In Figure 6 (a) the temperature swing is minimum when the insulation is placed on the outer surface of the wall (IM). For the other two formations (MI and MIM) the swing is higher. For $a_s = 1$ it is $sw_{IM} = 0.70\ ^oC$, $sw_{MI} = 0.83\ ^oC$ and $sw_{MIM} = 0.97\ ^oC$. As shown in Figure 6 (b), by placing one layer on the outer surface and the other on the inner surface (IMI) the temperature swing is minimum. For the remaining two formations (IMIM and MIMI) the swing is higher. For $a_s = 1$ it is $sw_{IMI} = 0.44\ ^oC$, $sw_{IMIM} = 0.55\ ^oC$ and $sw_{MIMI} = 0.62\ ^oC$. Thus, the placement of the insulation, wherever possible, in two layers decreases significantly the temperature swing on the inner surface of the wall.

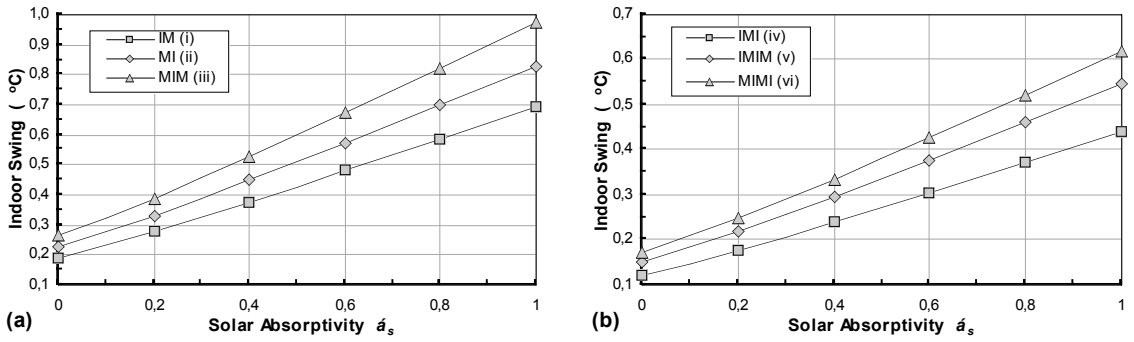


Figure 6 Indoor temperature swing vs. solar absorptivity for six wall formations with insulation as: (a) one layer and (b) two layers.

4. CONCLUSIONS

The present study was focused on the effect of solar absorptivity on thermal inertia factors for a number of insulated brick-wall formations. The influence of solar absorptivity on the brick-wall inner surface temperature swing has been also examined. The investigation was carried out for several wall formations with exterior/interior coatings and one or two insulation layers. These layers have been placed on the outer, inner and mid-center planes of the brick-wall. Simulation results have been obtained by employing a dynamic thermal-network model that has been analysed in discrete time steps, using the nodal approach. It has been shown that solar absorptivity, which affects the exterior forcing function (sol-air temperature), has a very profound effect on the thermal inertia factors. The increase of solar absorptivity up to 0.2 has caused time lag also to increase, but its further increase has led to the decrease of time lag. As the exterior coating-colour has become darker the decrement factor and the temperature swing have decreased and increased, respectively. The two-layer allocation of the insulation has shown to improve substantially the thermal inertia factors; furthermore, large indoor temperature swings have been avoided. Maximum time lag has been obtained with one insulation layer on the outer surface and the other in the mid-center plane of the masonry (IMIM). The minimum decrement factor and indoor temperature swing have been obtained by placing the two insulation layers on the outer and inner surfaces (IMI). The results presented in this study can have an important bearing when considering the design of passive buildings, from the point of view of the influence of solar absorptivity on the shift of indoor maximum temperatures, as well as on the interior temperature fluctuations.

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Comparison of Buildings-assessment Results of Green housing in Japan by using Eco Homes, LEED , GBTool and Green housing A-Z.

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1. INTRODUCTION

Since beginning of 1990's, environmental issue has become a matter of concern in architectural community. It is discussed what is green building and high performance building. Meanwhile, what is drawing the attention of the world is development of environmental performance assessment methods and tools. On the other hand, there is no building environmental assessment tool in Japan today. The purpose of this study is to know the key issues for development of environmental performance assessment method in Japan. A multi unit residential house in Japan was evaluated by 3 major assessment methods and Japanese check list formed method.

2. SUMMARY OF EACH ASSESSMENT METHOD

There are 3 famous assessment methods, BREEAM developed by BRE of Britain, LEED™ developed by US-Green Building Council, and GBTool developed by NRCan and 14 countries. In Japan, "Green Housing A-Z" was published from the Association for Environmentally Symbiotic Housing as an assessment and design guide.

2.1 EcoHomes

EcoHomes is the housing version of BREEAM, which is accepted at the general market and is actually used in these days. The assessment of EcoHomes is executed by the qualified person. The assessment category is divided into seven categories, "Energy", "Transport", "Pollution", "Material", "Water", "Land use and ecology" and "Health and well-Being". The final assessment result is shown as in four stages of "Pass", "Good", "Very good" and "Excellent" based on the total points.

2.2 LEED™

LEED™ was developed for the purpose of establishment of the environmental performance assessment method of building, and the definition of a high performance building in United States. LEED consists of six assessment area, "Sustainable site", "Water efficiency", "Energy and atmosphere", "Material and resources","IEQ" and "Design process". Assessment result is shown as in four stages of Bronze, Silver, Gold, and Platinum. The current version of LEED is developed for commercial building assessment but it is applied to residential building in this study.

2.3 GBTool

GBTool is the environmental performance assessment method and program which were developed as part of GBC'98 and GBC2000 project by 18 countries participation.
GBTool version 2002 is developed this year but GBTool version 2000 was used in this study.
The assessment area is classified into seven area; “Resource consumption”, “Loadings”, ”IEQ”, “Quality of service”, Economics”, “Pre-Operation management” and “Urban context”. The assessment result is shown as the score from –2 to +5 in each assessment categories.

2.4 Green Housing A-Z

Green Housing A-Z is the design guide and design check list to promote ecological housing and green housing in Japan. It consists design section, assessment section and reference data section. In the assessment section, there are three assessment methods; comprehensive checklist method for planning, primary performance assessment method and life cycle impact assessment method. The checklist assessment method was used in this study.

The comprehensive checklist covers “Energy conservation”, “Use of resources”, “Ecological value”, “Relation between indoor and outdoor”, “Safety and health” and “Habitat and symbiosis activity”. Every assessment criteria are scored according to qualitative judgments, whether environmental techniques are applied to the project or not. The assessment criteria are divided into the principal criteria and complementary criteria. The assessment result is shown as score points from 0 to 3 in diagram.

Table1 Outline of Assessment methods

Assessment method and criteria		Points	he number of criteria
EcoHomes	Energy	44	5
	Transport	14	4
	Pollution	28	2
	Materials	31	4
	Water	30	1
	Land Use and Ecology	36	3
	Health and well-being	24	2
	Total	207	21
Assessment method and criteria		Points	he number of criteria
LEED	Sustainable Sites	14	8
	Water Efficiency	5	3
	Energy and Atmosphere	17	6
	Materials and Resources	13	7
	Indoor Environmental Quality	15	8
	Innovation & Design Process	5	2
	Total	69	34
Assessment method and criteria		Points	he number of criteria
GBTool	R:Resource Consumption		6
	L:Loadings		11
	Q:IEQ		14
	S:Quality of Service		15
	E:Economics		3
	M:Pre-Operation management		12
	C:Urban Context		22
	ESI:Environmental Sustainability Indicators for Design		
	Total		83
Assessment method and criteria		Points	he number of criteria
Green A-Z	1.Energy conservation and use of renewable energy		17(10)
	2.Use of resources and reduction of waste		18(10)
	3.Ecological value and harmony with surroudings		17(12)
	4.Relation between indoor and outdoor		17 (6)
	5.Safty, health and comfort		13 (7)
	6.Habitat and symbiosis activity		11 (6)
	Total		93

3. THE OUTLINE OF CASE STUDY BUILDING

The case study building is a multi unit residential house in Japan, which is designed to be an energy conservation, long life, healthy and symbiotic housing in collaboration with the building owner, designers and engineers. Existing trees are saved, building block plan is

decided considering wind flow and sunlight, a flexible dwelling unit plan, the newest equipment, etc.

Table 2 Summary of the case study building

	Building Size
Site area Building area Gross area Building Population	4,768 m 2(Family) 896 m 2 4,811 m 2 200 person

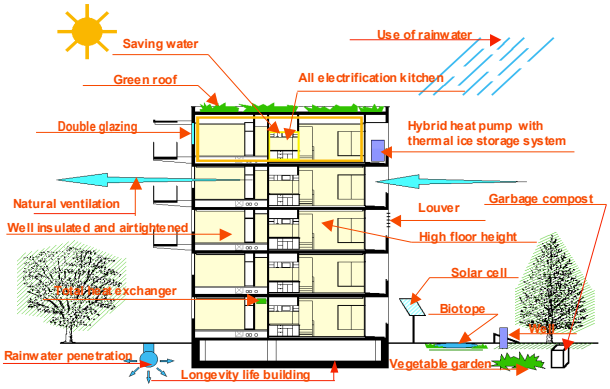

Fig 1 Section of the case study building

Table 3 Main environmental feature of the case study building

Item	Main environmental feature
Energy	Thermal insulation:50mm, double grazing, green roof High performance heat pump, thermal ice storage Natural ventilation and cross ventilation Louver, Green wall surface
Optimize solar and renewable energy use	Block plan is designed to give maximum effect of solar and seasonal wind, and considering the surroundings Openable windows are equipped each direction Solar PV is equipped on the roof
Structures and material	Separation of skeleton and infill High story height and double floor
Construction and operating wastes	Composting facility is equipped in the common garden Separate storage place of solid and organic is provided for each dwelling unit in service balcony
Reduce the use of automobile	150 bicycle parking spaces are provided
Indoor and outdoor environment	24 hours ventilation, heat exchanger Openable windows in all rooms Building envelop is well insulated and airtightened Biotope, vegetable garden, fruit tree forest, and play ground
Longevity	Skeleton and infill Flexible floor plan High durable concrete Access floor
Design process	Case study building is designed to be an energy conservation, long life, healthy and symbiotic housing in collaboration with the building owner, designers and engineers.

4.ASSESSMENT RESULT

4.1 EcoHomes

The assessment result by EcoHomes is shown in Fig. 2. The total assessment points are 117 points and the assessment result shows that case study building is in Good level.

4.2 LEED™

The assessment result by LEED is shown in Fig. 3. The total assessment points are 34 points and the assessment result shows that case study building is in SILVER level.

4.3 GBTool

The assessment result by GBTool is shown in Fig.4. In the assessment area of Resource consumption, the score of life cycle energy is 2.0, use of land is 1.5, use of water is 1.0, and consumption of materials is 0.8. In the assessment area of Loadings, the score of greenhouse gas is 1.0, emission of ODP is 4.0, emission of gas leading to acidification is 2.0, solid waste is 4.0, liquid effluent is 1.1 and impacts on site is 3.3. In the assessment area of IEQ, the score of air quality is 3.8, thermal comfort is 4.2, daylighting and illumination is 3.8, and noise and acoustics is 3.0. In the assessment area of Quality of service, the score of flexibility and adaptability is 3.5, controllability of system is 3.7, maintenance of performance is 3.8 and quality of amenity is 4.2.

4.4 Green Housing A-Z

The assessment result by Green Housing A-Z is shown in Fig. 5. Every principal assessment criteria obtain nearly full points and the assessment area of Ecological value and Relation between indoor and outdoor obtain high points.

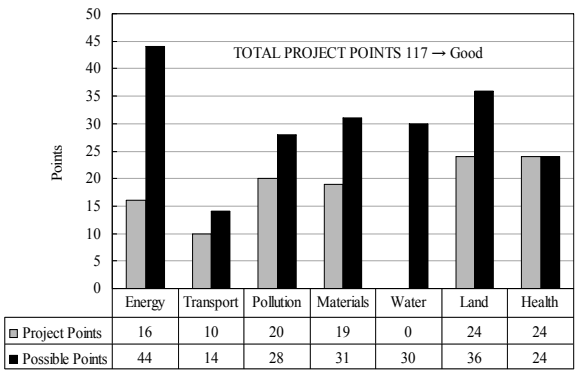

Fig2 Assessment result by EcoHomes

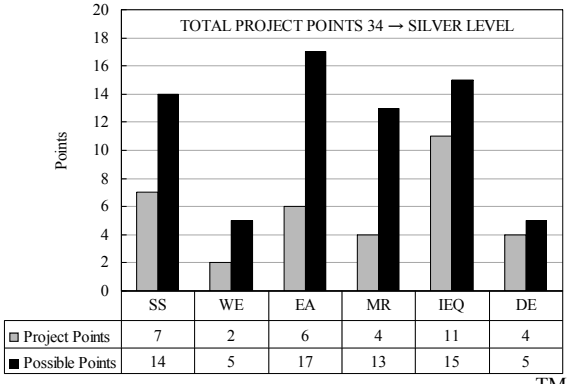

Fig3 Assessment result by LEED™

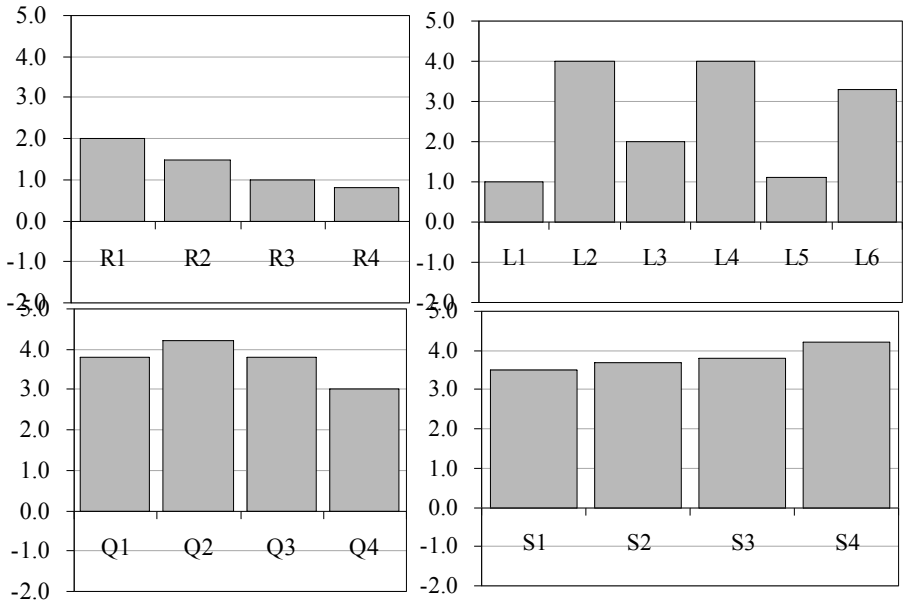

Fig 4 Assessment result by GBTool

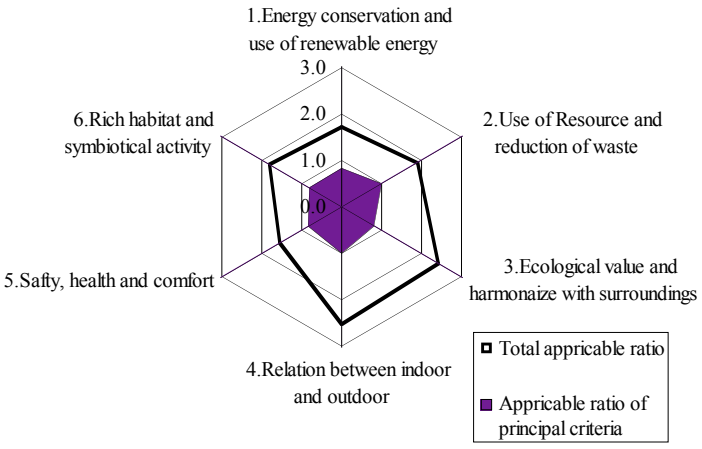

Fig 5 Assessment result by Green Housing A-Z

5. COMPARISON OF EACH ASSESSMENT RESULT

In order to compare the results of each assessment methods, the assessment criteria are re-classified into 4 assessment areas; SITE, ENERGY, MATERIAL and IEQ, and assessment points or score are shown as the ratio of the obtained points to full points in each assessment area. SITE includes land use, ecological value, rainwater management, transportation, surroundings environment and so on. ENERGY includes embodied energy, operating energy, building envelope performance, CO2, SOx, NOx, CFC and use of water. MATERIAL includes recycle and reuse materials, use of existing building, management of waste and use of authorized wood. IEQ includes thermal environment, ventilation performance, daylighting, illumination, noise, acoustic and so on. Fig. 6 shows the reclassified assessment results by EcoHomes, LEED^{TM}, GBTool and Green Housing A-Z.

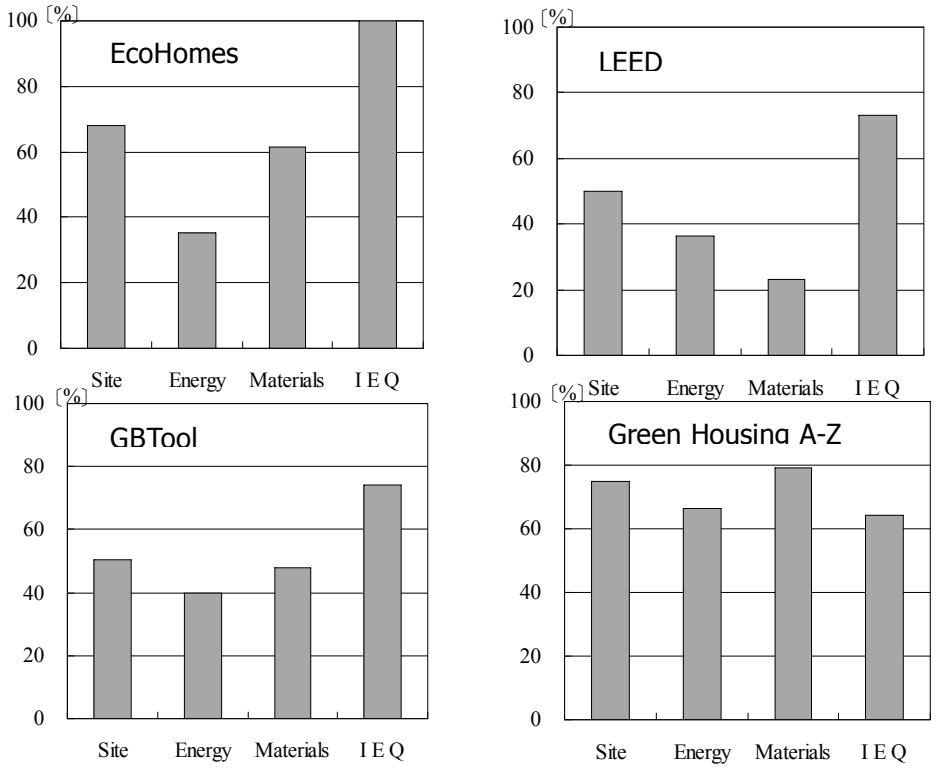

Fig. 6 Reclassified assessment result, EcoHomes, LEED, GBTool and Green Housing A-Z

The results of each assessment methods show the similar trends except Green Housing A-Z. The assessment area of ENERGY obtains lower ratio compare to the other assessment areas though energy saving issued are considered in the case study building. It shows that it is difficult to get high score in this area and the benchmark of energy issues is relatively high. The area of IEQ obtains the highest ratio and it is shown that the consideration to the indoor environment is adequate. The assessment area of MATERIAL in LEED obtains lower point ratio for there are many assessment criteria relating reuse issue, which are not considered in the case study building. Assessment score and points based on qualitative judgments would tend to be higher than based on the quantitative judgments.

6.CONCLUSION

A multi unit residential building in Japan was assessed by 4 different assessment methods in this study. Each assessment results show similar trend and Eco Homes, LEED and GBTool would bring equal assessment result. Some assessment criteria in each method require some standards and benchmarks, which are still not established in Japan. It took more than a month to collect the plan, various document and various building performance data and to implement assessment of the case study building. According to the questionnaire survey in Japan, many people think that assessment process should be within a few days or one week, so assessment process should be simplified. For developing assessment method in Japan, it is necessary to consider that establishing appropriate benchmark, selecting appropriate assessment criteria, assessment implementation timing, and simplify assessment process and technique.

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Estimation on the reduction of energy consumption and CO2 emission by introducing energy saving methods on all buildings in Japan

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1. INTRODUCTION

The world is getting more concerned with the environmental issues, and energy consumption and CO2 emission of buildings are one of large environmental matters.
The energy code was revised in 1999 in Japan, and the techniques of high insulation, air tightness and high efficiency equipment have been introduced.
The purpose of this study is to estimate the reduction of energy consumption and CO2 emission when the energy performance level of all buildings would be changed to the level of new energy code.

2.BUILDING STOCKS IN JAPAN

The total floor area of all building and detached house from 1960 to 1998 are shown in Fig.1, and total floor area of all buildings is showed in table1. In 1998, the total floor area of all building in Japan is about 5,371 million m^2. Among this data, total floor area of detached house is about 3,475 million m^2 and the total floor area of an apartment house is about 957 million m^2, the total floor area of an office building is about 485 m^2.

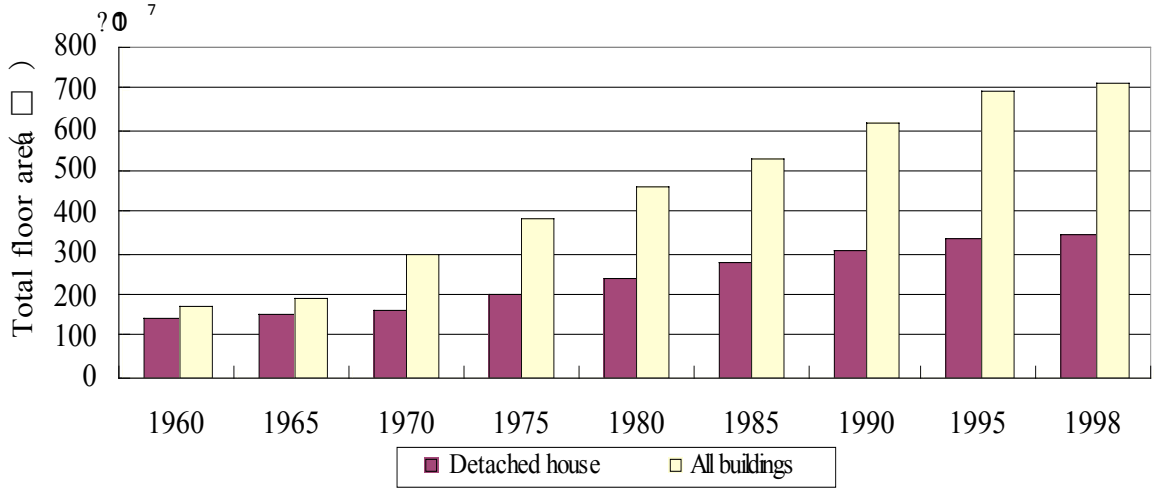

Fig.1 Transition of building stocks in Japan, since 1960 to 1998

Table1 Building use and Building stock in Japan, 1998

Building use	Building Stock (Million ㎡) 1998
Detached house	3,475
Apartment house	941
Office	485
Store	224
Hotel and Hospital	148
Factory	87
Warehouse	11
Total	5,371

Note: Stock of factory shows foods factory and stock of warehouse shows refrigerated warehouse.

3.OUTLINE OF ENERGY SAVING METHODS AND CALCULATION

The model for detached house, apartment house, office, retail house, hotel, factory and warehouse were set and energy simulation was carried out. Two models are set for each building, one is reference model based on the old energy code and the other is energy saving model based on the new energy code. The performance of insulation, air tightness, air conditioning, lighting and equipment system are revised in the energy saving models.

Total amount of energy consumption and CO2 emission of all buildings were acquired by multiplying the building stock data and energy consumption and CO2 emission of the model buildings.

According to the new energy code, the energy-saving techniques vary for every area and building use. The energy-saving technique of a single-family house and an office building in Tokyo is shown in Table 2 as example.

Heat insulation specification of a reference model building is set up based on old energy code in 1980 and heat insulation specification of an energy-saving model building is set up based on new energy code in 1999.

Table 2 Energy-saving technique in Tokyo area

	Single-family house		Office building	
	Reference model	Energy-saving model	Reference model	Energy-saving model
Heat insulation	Roof: GW35mm Wall : GW25mm	Roof: GW160mm Wall : GW90mm	Roof: 50mm of foaming systems Wall: Foaming system 15mm	Roof: 150mm of foaming systems Wall: Foaming system 75mm
Opening	Single glass	Double-glazed glass + Wooden (resin) fittings	Single glass	Double-glazed glass
Air conditioning equipment	Heat pump Air-conditioner	Heat Pump Air-conditioner + Heat exchanger	Multi-system	Multi-system + Heat exchanger
Lighting	Common lighting	Efficient 30% lighting	Ceiling lighting	A task / Ambient lighting
Ventilation control	-	-	With no control	Those with control

Table3 Outline of Model building

Building use	Total floor area (m^2)	Number of story (story)
Detached house	125	2
Apartment house	3,000	3 (40dwelling units)
Office	1,250	3
Store	13,230	2
Hotel and hospital	5,111	5
Factory	3,000	1
Warehouse	700	1

4. ESTIMATION OF ENERGY CONSUMPTION

The cooling load and heating load of each model buildings are calculated by using the dynamic cooling and heating load calculation program SMASH(IBEC) and Micro Peak (Construction equipment engineer association), and the amount of energy consumption by air conditioning equipment, lighting, and various equipment was calculated based on the cooling and heating load.

The amount of primary energy consumption was obtained by multiplying the energy consumption and conversion value.

Primary energy conversion value: Gas 46.044 (MJ/m3)
Electric power 10.255 (MJ/kWh)

Table 4 Calculation result of energy consumption of all buildings

	Reference Bldg. The amount of Energy consumption (1000 TJ/a year)	Energy-saving Bldg. The amount of energy consumption (1000 TJ/a year)	The reduction of energy consumption (1000 TJ/a year)
Detached house	2,447	1,684	763
Apartment house	359	240	119
Office	707	468	239
Store	526	336	190
Hotel and hospital	361	235	126
Factory	338	249	89
Warehouse	151	148	3
Total	4,889	3,360	1,529

5. ESTIMATION OF CO2 EMISSION

CO2 emissions was obtained by multiplying the conversion value of CO2 and the amount of electric power consumed in a building, the amount of gas, and the amount of oil(Table 4).

CO2 emission: Gas 2.354 (kg-CO2/m3)
Electric power 0.467 (kg-CO2/kWh)
Oil 2.529 (kg-CO2/liter)

Moreover, the economic effect accompanying the reduction of energy consumption was calculated from average unit price of gas, electric power and oil (Table 5). The energy prices vary in different location in Japan. Here, the average unit price of Tokyo Electric Power, the average unit price of Tokyo Gas was used as the representative value. About oil, the value of the Input/Output table 1995 of Japan was used.

Table5 Calculation result of CO2 emissions from all buildings

	Reference Bldg. CO2 emissions (1000t-CO2/year)	Energy-saving Bldg. CO2 emissions (1000t-CO2/year)	The amount of CO2 curtailment (1000t-CO2/year)
Detached house	111,503	76,622	34,880
Apartment house	16,343	10,903	5,439
Office	32,162	21,282	10,880
Store	24,741	15,783	8,958
Hotel and hospital	17,250	11,087	6,163
Factory	15,403	11,315	4,088
Warehouse	6,846	6,713	133
Total	224,247	153,706	70,541

Table 6 Economic effects by energy-saving measure

	Reference Bldg. (100 million yen/ Year)	Energy-saving Bldg. (100 million yen/Year)	Economic effect (100 million yen/Year)
Detached house	60,929	43,903	17,026
Apartment house	11,222	8,411	2,810
Office	16,014	12,764	3,250
Store	9,896	7,203	2,692
Hotel and hospital	5,417	3,301	2,116
Factory	5,469	4,515	954
Warehouse	2,669	2,646	23
Sum total	111,615	82,743	28,872

6. THE REDUCTION OF CO2 EMISSION BY ENERGY SAVING MEASURES IN HOUSING

The ratio of energy saving effect on reduction of CO2 emission are 19% of improvement in a heat insulation performance, 7% of improvement in an airtight performance, 11% of improvement in a heat insulation performance of a opening, and 63% of lighting and equipment. In the apartment house, 16% of improvement in a heat insulation performance, 11% of improvement in a heat insulation performance of a opening, and 73% of lighting and equipment (Tables 6 and 7). Since the power consumption of an air-conditioner, a refrigerator, TV, etc. assumed that it reached to 50% from various data in the future, the rate of the energy-saving effect by efficient-izing of lighting and equipment is large.

Table 7 Reduction of CO2 emission by-measures, all detached house (1000t/(year))

Area	Thermal insulation	A raise in airtight	Opening	Lighting	Equipment	Total
I	436	470	457	138	1,277	2,778
II	504	186	159	205	925	1,978
III	889	425	348	586	2,424	4,673
IV	4,526	1,298	2,933	3,657	12,051	24,466
V	262	55	87	135	445	985
Total	6,617	2,434	3,983	4,722	17,123	34,880

Table8 Reduction of CO2 emission by-measures, all apartment house (1000t/(year))

Area	Thermal insulation	Opening	Lighting	Equipment	Total
I	98	85	30	230	443
II	20	11	11	47	89
III	56	31	44	170	301
IV	698	467	796	2,570	4,532
V	14	7	13	40	74
Total	886	601	894	3,058	5,439

Note:The energy code divides the national land into 6 regions based on the climate condition but it is shown as 5 regions in this paper.

7. RESULT AND CONCLUSION

In 1998, the total floor area of all building in Japan is about 5,371 million m^2. Among this data, total floor area of detached house is about 3,475 million m^2 and the total floor area of an apartment house is about 957 million m^2, the total floor area of an office building is about 485 m^2.

If the energy performance level of all building in Japan would be changed to the level of new energy code, the reduction of energy consumption is about 1,529,000(TJ／year) and the reduction of CO2 emission is about 70,541,000(t -CO2／year). It is equal to about 5.4% of total amount of CO2 emission in 1995, Japan.

If the energy performance level of all houses in Japan would be changed to the level of new energy code, the reduction of energy consumption is about 882,000(TJ／year) and the reduction of CO2 emission is about 40,319,000(t-CO2／year). It is equal to about 57% of total reduction of CO2 emission from all buildings.

Acknowledgement:

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Synthetic evaluation of environmental impact of a small-scale building

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1. INTRODUCTION

Buildings cause various environmental impact with material and energy consumption and environmental pollution during the lifecycle. The floor space ratio of small-scale buildings- 3,000m^2 or less- is more than 60 %(Figure 1. M. Yamazaki. 2001). They are important in terms of environmental load reducing from the construction industry. Energy consumption of a building - more than 3,000m^2 in the case of a office- is set a goal, and the building owner is obliged to submit a energy conservation plan by Law concerning the Rational Use of Energy in Japan. Nevertheless a small-scale building is not the subject of the law. The purpose of this study is to evaluate Life Cycle environmental load of a small-scale building in comparison with a middle-scale building, using a LCA case study approach.

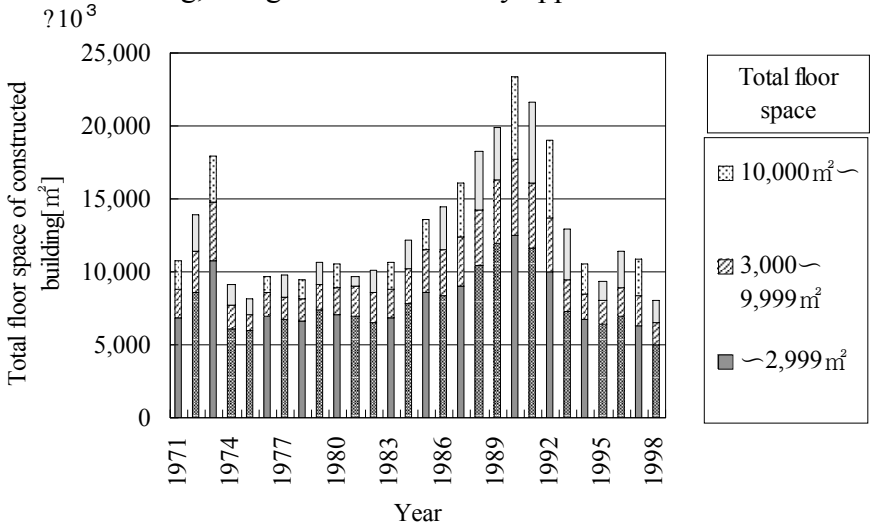


Figure 1 Floor space of constructed buildings in Japan.

2. METHOD DESCRIPTION

2.1 Scope

The scope is the environmental load from a building body and equipment during the life cycle.

2.2 Evaluation indexes

We studied on indexes to evaluate the environmental impact, relating to a building and an energy system. Table 1 shows the evaluation indexes. The indexes are three categories and nine sub-categories with hierarchical structure.

Table 1 Evaluation indexes.

Environmental Impact		Explanation	Inventory
Category	Sub-Category		
Global Environment Problems	Exhaustion of Resource	Exhaustion of Resource caused by spending energy resource-Oil, coal, natural gas, Uranium-, mineral resource-Steel, copper, aluminium, etc.-	Energy resource-Oil, coal, natural gas, Uranium-, mineral resource-Steel, copper, aluminium, etc.- consumption per year
	Global Warming	Global Warming caused by greenhouse gas(CO_2, CFC) emission	CO_2 emission and CFC leakage per year
	Ozone Depletion	Ozone Depletion caused by chlorofluorocarbon emission	Chlorofluorocarbon leakage per year
	Acid Rain	Acid Rain caused by Nitrogen Oxides and Sulfur Oxide emission	NOx and Sox emission per year
Regional Environment Problems	Air Pollution	Air Pollution caused by Nitrogen Oxides and Sulfur Oxide emission	NOx and SOx emission per year
	Expansion of Garbage Disposal Facilities	Expansion of garbage disposal facilities caused by generated waste on Construction, operation and demolition	Waste on construction, operation, demolition per year
	Expansion of Electric Power Plant	Expansion of Electric Power Plant caused by increase of electric demand for a building	Peak power in summer
Neighborhood Environment Problems	Heat Pollution	heat island phenomenon caused by an air-conditioning system emits waste heat	Waste heat an air-conditioning system emits per day on peak power day in summer
	Noise Emission	Noise Emission caused by operating an air-conditioning system	Noise of outdoor unit of operating an air-conditioning system

2.3 Process

1)INVENTORY ANALYSIS

We estimated the material consumption except for A/C system with written estimate of the similar buildings as the case study models.

We estimated the energy consumption by computer simulation assuming conditions close to the actual use and equipment with appropriate capacity. Especially, for the energy consumption of air-conditioning(A/C), we calculated each hourly load using the dynamic thermal load calculation software HASP/ACLD/8001(The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan 1980)and analyzed characteristics of the A/C system with some manufacturers' technical data. And we referred to the design guideline of Japanese public facilities(Former Ministry of Construction. 1998) as for the other energy (outlet, lighting and lift) simulation conditions.
We estimated each inventory per year except noise emission, assuming that the building life would be 40 years and the equipment would be renewed every 15 years.
2) CLASSIFICATION AND CHARACTERIZATION
The environmental impact had already been classified. Then we characterized the inventories using characterization factors. We used as scientific figures as possible(Table 2).

Table 2 Characterization factors

Impact(Sub-Category)	characterization factors
Exhaustion of Resource	equivalent weight of steel (calculated with annual consumption, proved resource and recycling rate)
Global Warming	Global Warming Potential(GWP) (Inter governmental Panel on Climate Change(IPCC) 1995)
Ozone Depletion	Ozone-Depleting Potential(ODP) (World Meteorological Organization(WMO) 1992)
Acid Rain	Acidification potential(AP). (Maximum) (Heijungs R. 1992)
Air Pollution	Weight based on the environmental criteria in Japan (Former Ministry of the Environment. 1993)
Heat Pollution	Influence by sensible heat and latent heat on ET* (Uchiumi. 1998)

3) NORMALIZATION
We defined the standard case - described later - to standardise the scale of each characteristic.
4) VALUATION
We integrated the normalized characteristics using the weighting factors - our group researched and found ones based on public sectors' concept of values(S. Banno 1999)-. We think using them is reasonable because Public facilities leads the private facilities into the sustainable ones.

2.4 Case Study Conditions
We performed a case study on 3 case(Table 3). Multi type A/C is increasingly installed recently, especially in small-scale buildings in Japan. So we assumed Multi type A/C, and

Heat pump chiller which was typical central system. And we set the standard case A1 for normalization.

3. RESULTS AND DISCUSSION

3.1 Material consumption

Table 4 shows the material consumption of the buildings' body. Although comparing them is difficult simply because of the difference of the structure, the material consumption of the small-scale building is 1.8 times as much as that of the middle-scale building. Because the area of the wall and the window of the small-scale building is lager.

Table 3 Case study model

	A1	B1	B2
Building scale	Small-scale	Middle-scale	
Total floor area	1,700m^2	6,800m^2	
Number of stories	10F	10F	
Area of typical floor	170m^2	680m^2	
Structure	steel framed reinforced concrete structure	steel structure	
Air-conditioning space ratio	65%	65%	
Air-Conditioning System	Multi type air-conditioner	Multi type air-conditioner	Heat pump chiller

Table 4 Material consumption of the two buildings' body.

	Small-scale building A [kg/m^2]	Middle-scale building B [kg/m^2]	A/B
Reinforcing bar	151.3	79.2	1.91
Steel-frame	260.6	270.1	0.97
Metal fittings	4.2	2.6	1.61
Stone	25.2	3.5	7.17
Concrete	3,675.0	1,926.5	1.91
Wood	16.0	1.7	9.20
Plastic	0.4	0.2	2.43
Others	13.1	0.0	-
Total	4,167.4	2296.9	1.81

3.2 Energy consumption

Figure 2 shows the energy consumption on operation. As for the total consumption, A1:B1:B2=1:0.90:0.94. As for the A/C operating consumption, A1:B1:B2=1:0.80:0.90. Therefore the energy consumption of the small-scale building is lager. Especially the energy consumption for the A/C is decided by the characteristics of the A/C load peculiar to the building, and it causes the difference between both cases. This is because the areas of the wall and the window of the small-scale building is larger. On the other hand, the energy consumption except for the A/C is in proportion to floor space, and decided by the building grade.

3.3 Environmental Impact

Figure 3 shows three of the results; Exhaustion of Resource, Global Warming, Acid Rain. About 70% of Global Warming impact is caused on operation. On the other hand, Exhaustion of Resource and Acid Rain impact on construction is lager than that on operation.

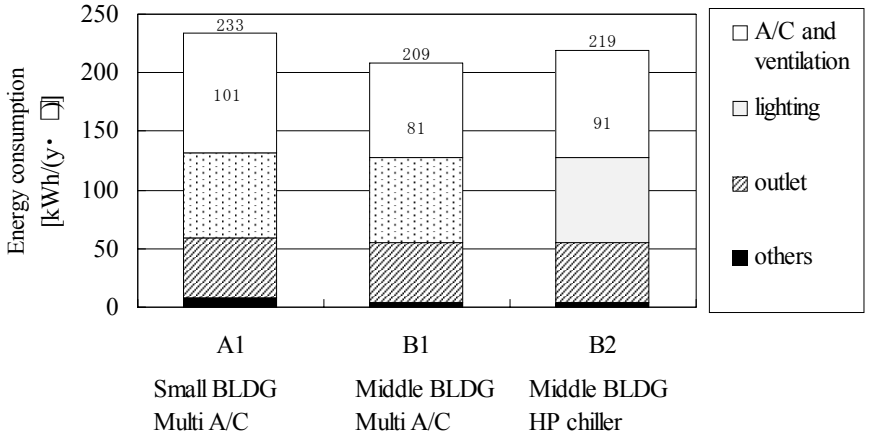
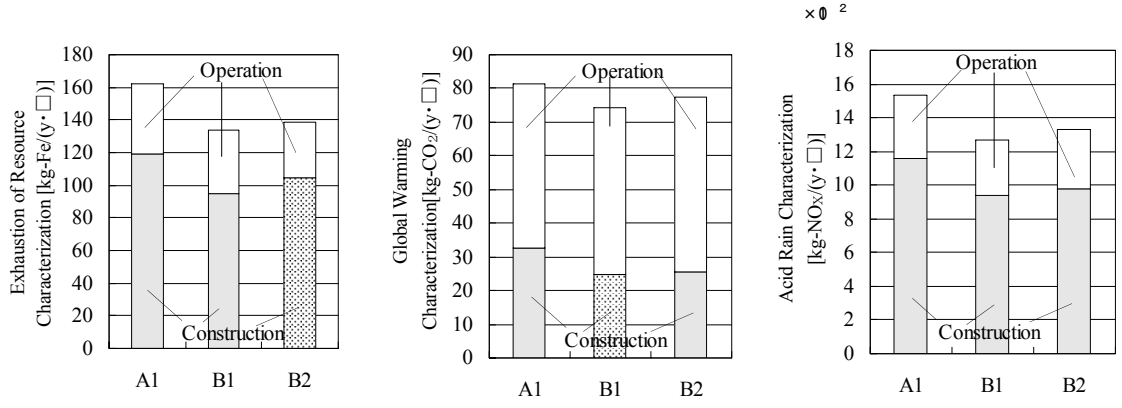


Figure 2 Energy consumption of each cases



Exhaustion of Resource Global Warming Acid Rain

Figure 3 Environmental impact (three of sub-categories)

3.4 Synthetic Evaluation

Figure 4 shows the result of synthetic evaluation of environmental impact of each cases. The impact of the small-scale building is largaer as each impact.

5. CONCLUSION

The energy consumption of a small-scale building are larger than that of a middle-scale building. Especially the energy consumption for the air-conditioning is decided by the characteristics of the air-conditioning load, and it causes the difference between both cases. On the other hand, the energy consumption except for the air-conditioning is in proportion to floor space, and decided by the building grade. Therefore, energy conservation for the air-conditioning is important to save energy consumption of a small-scale building. The material consumption of a small-scale building is also larger than that of a middle-scale building.

Due to the largeness of the material and energy consumption, the environmental impact of a small-scale building is larger as sub-categories except for noise emission. About 70% of Global Warming impact is caused on operation. On the other hand, Exhaustion of Resource and Acid Rain impact on construction is lager than that on operation. Further, the synthetic evaluation of environmental impact of a small-scale building is larger.

In Japan, small-scale buildings - less than 2,000m^2 - is not the subject of Law concerning the Rational Use of Energy. We suggest that it is important to work reducing environmental impact of small-scale buildings for the construction industry.

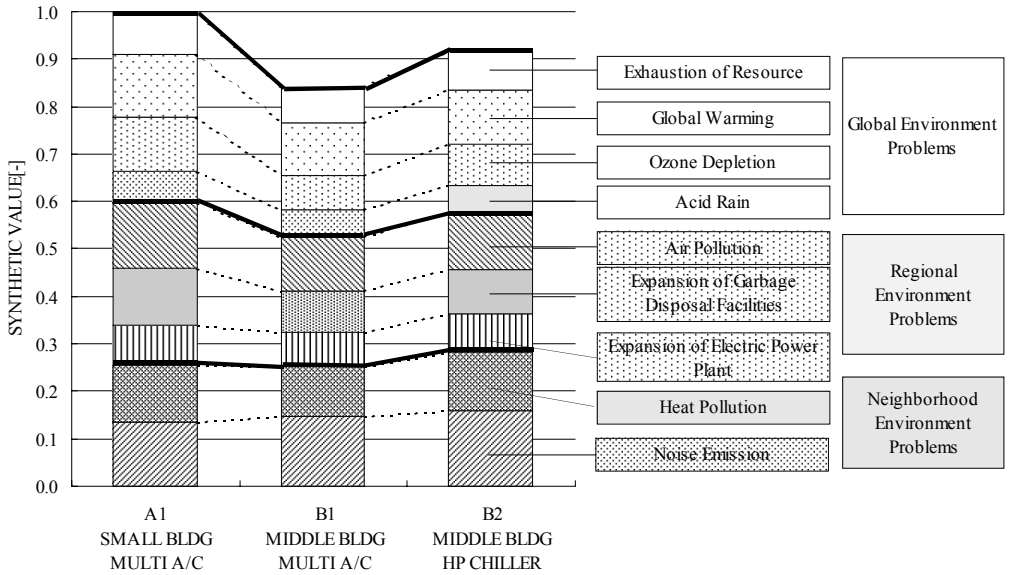


Figure 4 Result of synthetic evaluation of environmental impact of each cases

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Pilestredet Park in Oslo: Implementation of an environmental programme in large-scale urban development.

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1. INTRODUCTION

Pilestredet Park is located in the city centre of Oslo, at the site of the former National Hospital of Norway. The ground area is ca. 73 000 m2. Of the original buildings, containing 110.000 m2 gross floor area, 50.000 m2 will be demolished. New buildings will have 75 000 m2. Refurbished hospital buildings will have another 60 000 m2, giving a total of 135.000 m2 in the finished project. 900 dwellings are planned within the area, together with educational facilities, shops and offices.

550 of the 900 dwellings on 5 separate sites within Pilestredet Park will be built by a joint devevelopment venture established by the housing division of Selmer Skanska together with OBOS (Norway´s largest cooperative housing organization). The author is partner in GASA architects, who act as environmental coordinator. Together with Lund & Slaatto architects, GASA is also responsible for the arcitectural design of the housing projects of Selmer Skanska and OBOS.

Pilestredet Park marks a transition from small-scale pilot studies to large-scale urban implementation of principles for sustainable building in Norway.

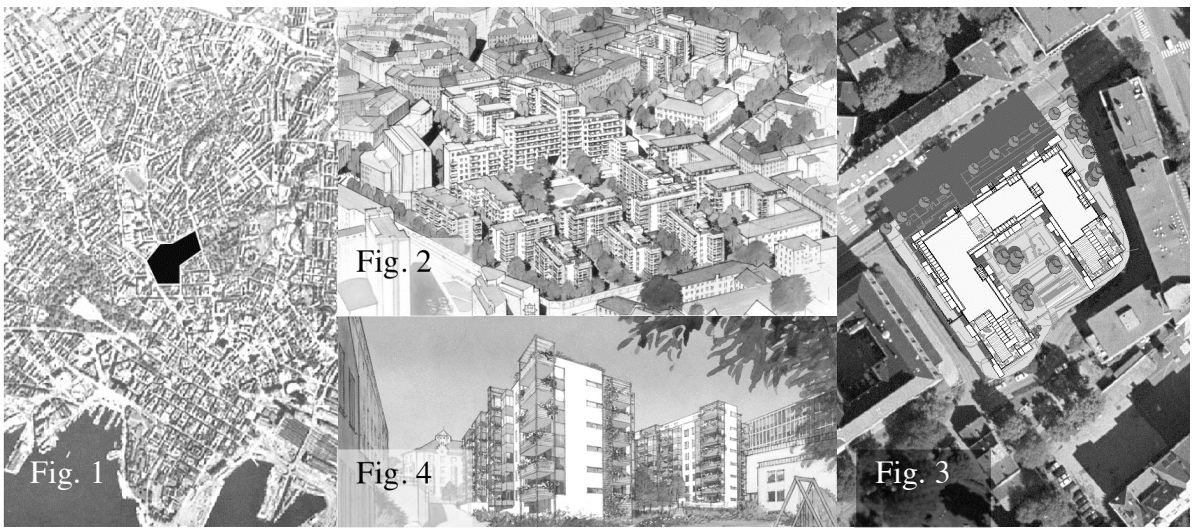

Fig. 1: Location of Pilestredet Park. Fig.2: Perspective overwiev. Fig. 3 and 4: Area H, containing the first 155 of a total of 550 dwellings to be built by Selmer Skanska and OBOS. The site plan (Fig.3 shows common roof terraces connected to each staircase.) Green roofs will be a distinct feature in the new housing projects in Pilestredet Park.

2. THE ENVIRONMENTAL PROGRAMME

For Pilestredet Park the Directorate of Public Construction and Property in Norway (Statsbygg) has formulated an environmental programme for the planning, construction and maintenance phases. The scope, the quantified aims and the legal, organisational and procedural commitment required from the developers sets this programme apart from comparable efforts in Norway.

2.1 The scope

Many projects labeled as sustainable have a narrow focus, often related to energy. The environmental programme for Pilestredet Park covers a very broad spectre of sustainability. issues. The titles of the main chapters of the programme are illustrative:

- **The utilization of resources:** General aspects, materials, water, energy. Waste during construction and use.
- **External environment:** Emissions to air, water, and soil. Avoidance of harmful materials.
- **Health, well-being and security:** Working environment during demolition, construction and maintenance. Indoor climate, including daylight. Transport. Landscaping.

2.2 The quantified aims

Environmental programmes have a tendency to be general, leaving ample room for interpretation by the developers. For Pilestredet Park, the aims are spesific and quantified. It may be argued that some are moderate, compared to the most advanced solutions. The principle of quantified aims is, however, important. A well documented failure to meet an aim proved irrelevant may be very useful to developers of future programmes and building codes.
Examples of spesific environmental aims in Pilestredet Park are:

- 90% reuse of demolition materials.
- At least 25% weight reused materials in new buildings and outdoor paving, landscape fillings etc.
- No use of materials containing over 0,1% weight) of chemical components on the OBS- list developed by the Norwegian Pollution Control Authority.
- Max tap water consumption 150litres per person and day.
- Max run-off of surface water for each area specified as a proportion of total allowed run-off for Pilestredet Park.
- Max energy consumption 100 kwh/m2/year, (Low-energy scenario in nordic climate, 30% less than recently revised building codes.)
- Waste for disposal less than 30% of total volume (both during construction and use).
- Max equivalent noise level 2dB(A) lower than city norm for Oslo.
- Max 10 person injuries resulting in more than one day of absence per million work hours.
- Maximum 1 water damage per 100 000 m2 built gross area and year.

2.3 The legal, organisational and procedural commitment required

The environmental programme clearly specifies the responsibilities of developers, consultants, contractors and users/dwellers. Coordinators shall be apointed for the design and planning process Procedures for documentation and external control are described.

Instructions are given to incorporate the programme in the contracts with developers. Sanctions are to be imposed if instructions are not followed.

3. STRATEGY FOR IMPLEMENTATION

The joint development venture (Selmer Skanska Housing / OBOS) commisioned architects and technical consultants to carry out preliminary design and documentation for public approval. A design and build contract, including the consultants´ detailed design and the following up during construction. was in turn negotiated with Selmer Skanska acting as total contractor. According to the environmental programme, deviations from the aims shall be noted and negotiated before public approval. Thus the implementation of the programme was dependent on systematic efforts during the first months of a very tight time shedule for design.

3.1 The environmental control plan

PILESTREDET PARK ENVIRONMENTAL CONTROL PLAN		PHASE: PRELIMINARY PROJECT				Page 4 of 7	
THEME		ENVIRONMENTAL AIM		SURVEY / ANALYSIS / DESIGN (DOCUMENTATION)	DEADLINE	FIRM/ORG.	PERS.	CONTROL
3. Water MOP 3.2.2	M	Use of tap water in dwelling areas shall be maximum 150 litres per person and day. Measurement of water consumption shall be possible in the individual flat. Quality water for drinking is an important health issue. Accordingly, only pipes and tubes shall be used that emits as little as possible of hazardous substances. Materials must also be safe during fire.	D	Establish capacity-defining situations for tap-water consumption. Design water supply system with water-saving components. Establish procedures for control of components regarding harmful emissions. Integrate measurement and payment systems that incites water saving. This system must be integrated with other systems.	15.09.00	HVAC= HVAC consultant	AV	EEC
MOP 3.2.2		Surface water: Max run-off (top capacity): 103 l/sec x percentage of area to total area of Pilestredet Park. Calculations must be submitted that verify that the aims for maximum run-off for the individual area is		Develop solutions that ensures the necessary delay in run-off of surface water. Coordinate plans with the overall landscape plan for Pilestredet Park. Develop designs that supports the use of water as a positive environmental component, and resource for watering	15.09.00	HVAC LARCH	AV AAS	EEC

Fig. 5

The key tool in the early implementation of the environmental programme was the environmental control plan. It was formed as a simple matrix, defining design, calculation or surveying tasks necessary to verify that the design met each of the detailed requirements. The outline of the control plan is shown in fig. 5. The aims of the environmental progamme are listed to the left. The actions to be taken, and the firms and persons responsible are described in the succeding columns.

3.2 The environmental control form

PILESTREDET PARK ENVIRONMENTAL COORD.		CONTROL FORM				
DATE:	SIGN.			PAGE 2 OF 6		
AIM IN PROGRAMME (MOP) OR SELF-DEFINED. AIM		DEVIAT. REPORT	DEVIAT. ACCEPT	AIM REVISED	SURVEY COMPL.	AIM FULLF.
Materials MOP 3.2.4.1	Minimum 90% (weight) of demolition materials shall be reused.	☐	☐	☐	■	■
	The materials shall be reused on highest possible level (minimum processing). Minimum 0,25% direct reuse, and	☐	☐	☐	■	■

Fig. 6

To ease the overview of the status of the implementation process, a diagrammatic table was developed. The basic lay-out of the control form is shown in fig. 6. Deviations from or modifications to the environmental programme are noted, and the prognosis for aim fullfillment is described.

3.3 A hierarchy of control documents

During the detailed design and construction phases, the implementation strategy was extended to a series of hierarchically structured control documents, shown in fig.7

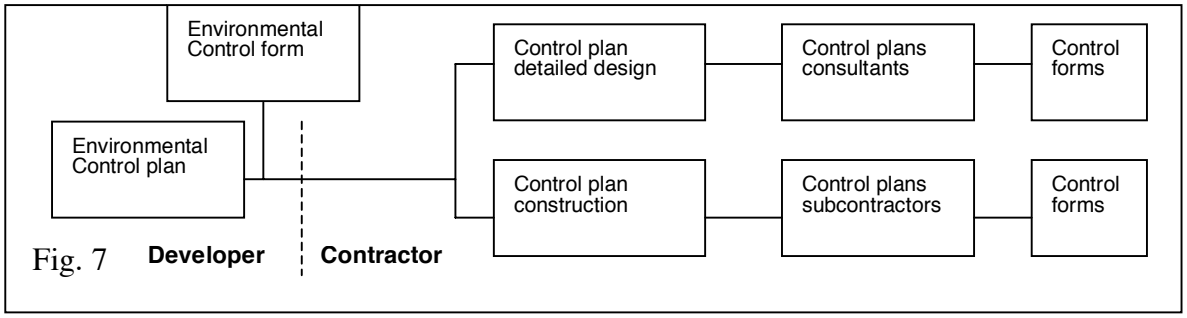

Fig. 7

4. EXPERIENCE GAINED DURING IMPLEMENTATION.

4.1 Tender and negotiation

On initiating the bidding process for the sites, the Directorate for Public Construction and Property (Statsbygg) were uncertain about price consequences of the envrionmental programme. The bids turned out to lay within market expectations.

During preliminary design, the number and quality of flats, the area effectiveness of the plans, and the rationality of the constructions and HVAC systems were closely monitored. The environmental control plan was essencial in the early evaluation of the economical implications of the aims for sustainability. At the time of writing, stable sales indicate that the environmental performance is not a threat to the economical.

The ambitious programme, the open tender and the following negotiatons put considerable pressure on the participants. At the same time, the results of the process are more likely to be applicable throughout the industry.

4.2 Organisation and people.

Environment-friendly innovation must be backed by central management and embedded in adecquate business strategies. But changes in priorites and behaviour also requires people with enthusiasm and stamina. In the Pilestredet Park case, Selmer Skanska´s own environmental department, led by Hilde Hermundsgård Reine, had developed in-house expertice, leading to certification according to ISO 14000. They were able to allocate adequate resources to the collection and structuring of relevant product data. In the OBOS organisation, architects Mette Sjølie and Per Andersen had gained considerable experience from environmentally oriented projects, and contributed during the crucial, initial design phases.

4.3 Coordination and control.

Appointing environmental coordinators, both on the developer and the construction side has proved necessary to integrate the efforts to meet the environmental aims. The coordinators have interdiciplinary responsibilities, and should have experience from cross-professional team work. Arne Linja, an experienced building engineer, was appointed environmental coordinator for the contractor, backed by an enthusiastic team handling subcontracting and site management.

The traditional split between design and construction, even whithin total construction firms, represents a coordination problem. The coordinator at Pilestredet Park came from the construction side. To ensure implementation of the programme, separate control plans were made for construction and detailed design.

As coordinator for the developer, the author specified that the environmental programme should be integrated into the ordinary control systems being used by all participants during planning and construction. At the time of writing, this has been done by the architects, but it remains to be seen how deep this integration will reach.

It is the author´s firm belief, based on experience, that separate control systems related to different codes, regulations and programmes represents a quality and safety risk. Real control.requires integration of control systems.

4.3 The programme

During the initial design phases, the environmental programme was put to test. Most of the aims has proved relevant, and a challenge, whithout demanding exessive efforts. Some requirements, however proved inadequate, impossible or unreasonable, and were modified after negotiations with Statsbygg. These are some examples:

- The detailed town planning regulations specified building locations and sizes that excluded daylight factors of 2% in many of the dwellings. The daylight analysis was presented to Statsbygg, and the requirements modified.
- The planning regulation also required stepped-back top floors with private roof terraces. It turned out to be difficult and unfunctional to build large roof terraces, specified in the envrionmental programme, on top of such top floors. Again, negotiations resulted in a compromise. The common, green roofs will be built, but the form and location will vary according to the regulations of the site.
- The requirement for 3 in-house bicycle places in an area with an expected occupancy of 1,66 persons per flat was questioned. This demand turned out to be expensive, and resulted in larger basement areas and increased excavations. The requirement was reduced to 2,5 places per flat.
- Methods for measurement of local dust spreading proved inadequate, and alternative strategies were tried out in cooperation with Norwegian Institute for Air Research (NILU). Selmer Skanska ended up building their own dust measurement station.
- Demands for reduced noise levels during construction were impossible to meet for some processes (for example pole ramming). Instead, a scheme for time limitiation was agreed upon with the local health authorities, together with a neighbourhood information plan.

On a more general level, the environmental programme appears to reflect the strength and the priorities of the expert groups that developed it. The materials section is long and very detailed. The chapters on energy and water are much shorter, and in the case of water, less ambitious than both energy and materials. This indicates that a calibration process should have been carried out, aiming to coordinate the strength of the requirements, anchoring them in an overall priority of environmental issues.

The programme, however, still stands out as the most ambitious, thorough and operative one made by a State agency for a large project.

5. PRELIMINARY RESULTS

At the time of writing, the first of five sites are in an andvanced state of construction. So far, several important results have been achieved:

- Untypically, compared to many recent developments, the most attractive roof terraces are reserved for common use by the dwellers in each appartment block. The roofscapes shall meet aims for size and coverage with plants of different sizes.

- Measures for time-limitation of noise production, reduced dust spreading and cleaning of transport vehicles has reduced negative impact on surrounding areas.
- More than the required 90% of the demolition materials are being reused. Pilestredet Park contains large demolition projects, so this indicates that a major building industry waste source can be virtually eliminated.
- More than the required 70% of construction waste is being reused or recycled. Traditionally, 40% of the waste for disposal comes from the building industry.
- A calculated energy consumption of 100 kWh/sqm.y has been achieved. The most important measures beeing improved insulation, a high degree of heat recovery and demand-controlled heating and ventilation. Calculated results will be tested via monitoring.
- Loads on urban pipe system is greatly reduced by on-site measures for delayed run-off. Tap water consumption calculated to be reduced to the required 150 litres pr. person and day.
- Extensive screening of materials vastly reduces the occurence of known harmful substances.
- A new type of prefabricated, hollow concrete floor elements has been developed to meet the aim of 25% reuse of materials in new constructions. This , in turn, has reduced the manufacturers´s environmental expenses.
- A 20-point programme has been developed to reduce water damage during construction, and to prevent negative impact on indoor climate.
- The combined effort of the "clean building site"-policy and the desentralized waste collection and sorting results in improved working environment.
- A specially developed information programme for workers on site secures the implementation of the environmental programme. Innovative solutions has come out of this.

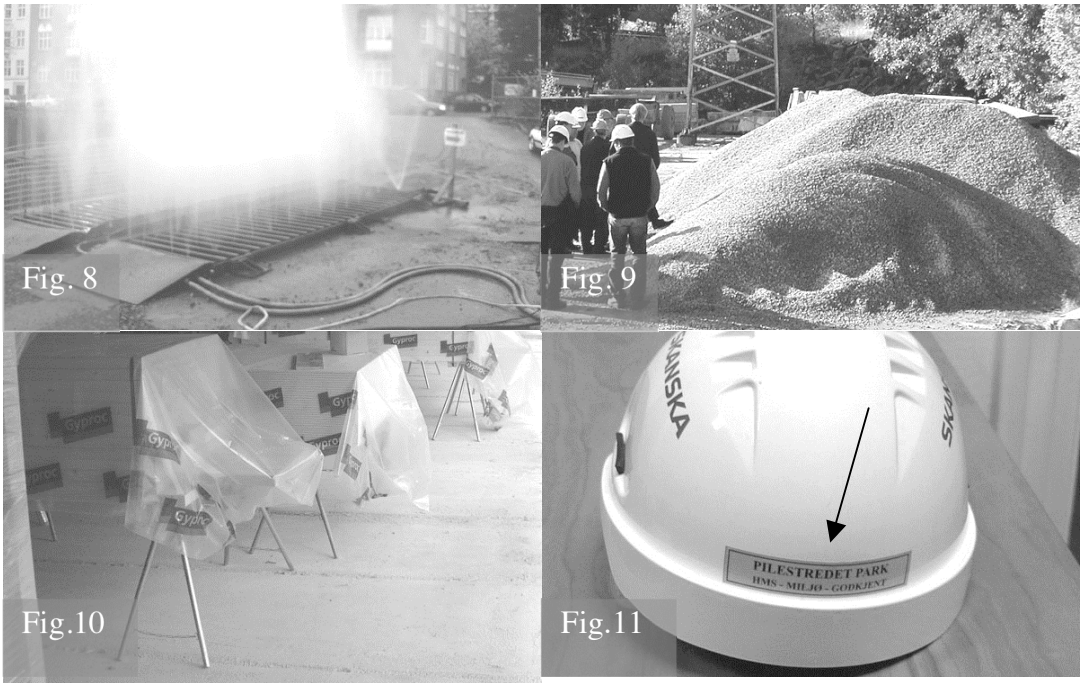

Fig. 8:On-site vehicle wheel cleaner. Fig.9: Grinded wasteproducts for reuse in concrete slabs. Fig. 10: elevated board stacks for easy floor cleaning and reduced manual lifting height.Fig.11: Helmet sticker certifying for on-site work after recieving information on environmental programme.

Building for reuse: Design strategies and supply logistics.

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1. INTRODUCTION

1.1 The site and the project

Every building is a structure at a certain point in a lifecycle, during which it is part of many subcycles. Sustained presence of high quality components in the lifecycles of buildings may be good for the environment, the architecture and the economy.

According to 1998 statistics, refurbishment and demolition accounted for 85% of the 1.9 million metric tons of waste produced by the building industry in Norway. The Norwegian Directorate of Public Construction and Property (Statsbygg) decided to carry out a preliminary project for "the Reused Building". This is intended to be a demonstration project for extensive reuse of building components and materials. It will be built in Pilestredet Park, the site of the old Norwegian State hospital.. The development programme asked for 43 flats, of which 20 should be designed for people in need of special service and care. Areas for local shops are supposed to be established on street level.

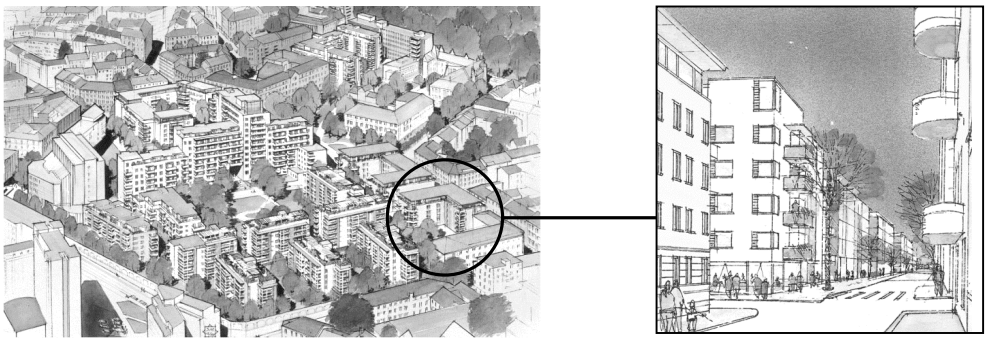


Fig.1 The site for the Reused building in Pilestredet Park in Oslo

1.2 The participants

Several teams competed for partnership during preliminary design. Veidekke ASA, the largest Norwegian contractor, in cooperation with GASA Architects AS were chosen. Later, Multiconsult AS, an interdiciplinary firm of consultants, joined the group. Petter Nøstdal from Veidekke was project leader. The author acted as envrionmental coordinator and led the design process together with Per Monsen, also from GASA.

Svein Bjørberg from Multiconsult, together with Hege Hansesveen from Veidekke, was responsible for research and development activities related to the project. Bjørberg developed many of the terms and process descriptions used in this paper.

1.3 The store of parts

Reusable materials were registered in "demolition catalogues" for each of the old hospital buildings. Valuable, carved stone components like sills, columns, portals and stairs were taken out and stored before demolition. Windows, doors and sanitary equiment were also saved. This store of parts was supposed to be considered for reuse, partly in the overall landscaping project, and partly in the Reused Building. The project was delayed compared to original plans. Therefore, it was decided to sell a larger portion of the wooden components, like windows and doors. The alternative was long-term cold storage, which might cause degradation before reuse.

Thus, the store of parts became smaller than intended. The upside to this is that it resembles a typical situation, where the search for reusable materials will be an integrated part of the design and construction process.

2. TERMS AND DEFINITIONS

Following studies of related litterature and public documents, *reuse* was selected as the common and general term. Reuse may be take the form *renewed use* or *regain.* Renewed use means to send a whole building or a component into a new lifecycle without changing it in a fundamental way. Regain implies reuse after or through processing. Windows that are cleaned and repaired may have renewed use in a refurbished facade. Wooden beams split into smaller parts represent a regain of resources, as does chopping them up and burn them to regain energy. Fig 2 sums up these basic concepts.

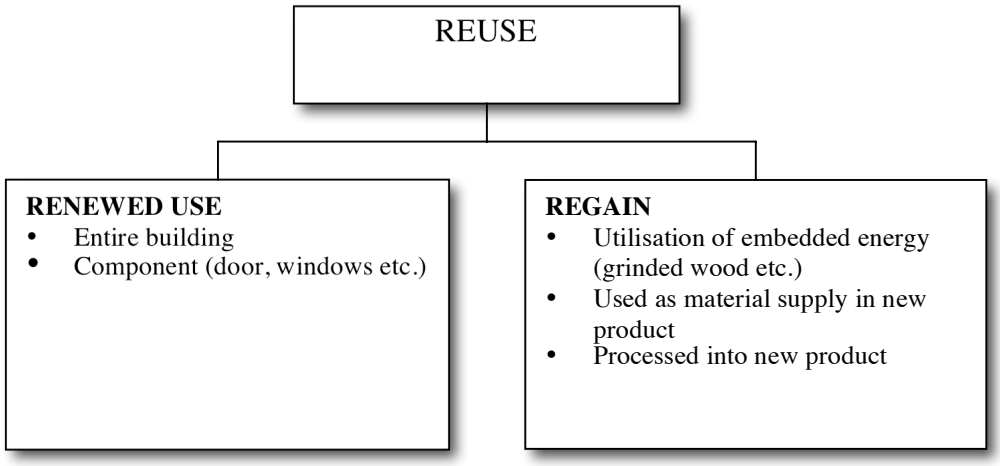


Fig.2 Basic terms

3. THE SUPPLY AND CONTROL OF MATERIALS FOR REUSE

The optimum situation would be to reuse demolition materials in new buildings on the same site. For the Reused Building, a base of materials and components is available. Delayed start of the project necessitated transport of materials for long-term storage on a site outside the city centre. This illustrates the logistical problems involved. The time of demolition can not be expected to coincide with the time for reuse in a new porject.

Another type of problem is related to the control of the quality and functionality of the materials that can be reused. Some components, like stone stairs, have unquestionable

durability. For many product groups, however, procedures has to be prepared that enables the designers to make quick evaluations. Issues related to warranties and liabilities must be clarified. As a part of the preliminary project, an integrated control document was developed to aid the search and selection of materials. Here, the checking of materials and components against different sets of requirements is done in one, coordinated operation.

In figure 3, the typical sources of materials for reuse are shown, together wth the processes leading up to reuse on site. Bound materials are structurally integrated with other products, like the steel reinforcement in concrete constructions. Unbound products, like bricks, may be reused in their original form or reprocessed into a new, bound form.

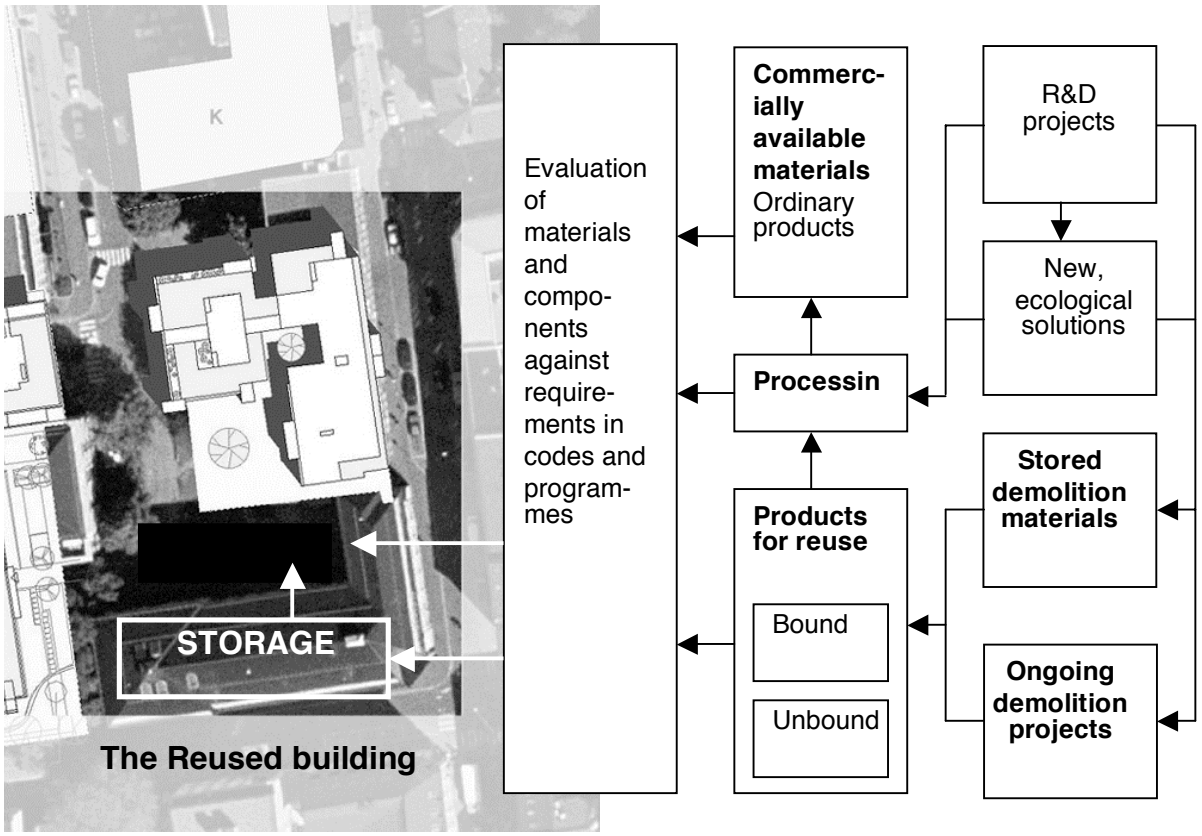


Fig. 3. *The Reused building. Sources of materials. Processes and logistics involved.*

4. DESIGN STRATEGIES

4.1 Professional challenges

Design for reuse challenges working procedures and role patterns in the industry:

- Architects must adjust to the idea that buildings may change architecturally over time. They even have to foresee the eventual dismantling or demolition of the building.
- The engineers must design for durability, not excluding easy exchange of components over time. Fire profing should be demountable, and not jeopardize future reuse.
- The quantity surveyors and financial advisors must dare to recommend solutions that may be more expensive on aquisition, but will prove more economical during use.
- The investors and keepers of properties should give priority to the long term advantages of systematic reuse. They should secure that future owners may benefit from these principles.

4.2 The architecture of reuse

Reused or recycled buildings often are associated either with a tuned-down urban classisism or crows´ nests of creative, do-it-yourself ad-hocism. Working with the Reused Building project, GASA architects have experienced that reuse put few restrictions on architectural themes and solutions.

New and old have been combined with great results (fig.4) One may use objects or forms that illustrate the history or special properties of the site. Traditional crafts may be contrasted with industrial processing. Interplay between rough and refined materiality in surfaces may be introduced as an architectural theme. If reuse is to be a widespread principle, series of examples must prove that it may play a positive role in contemporary architecture.

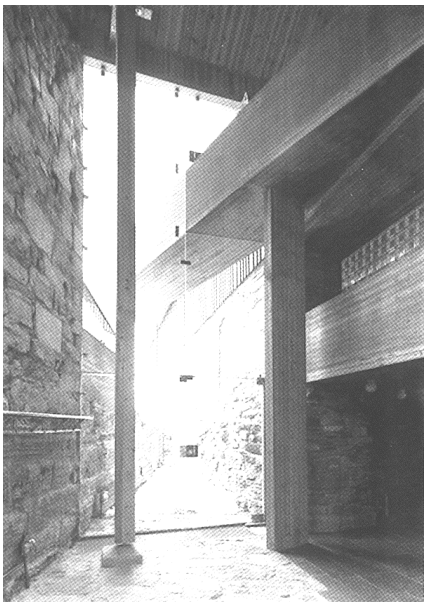


Fig.4 *Sverre Fehn: Museum at Hamar, Norway. Modern constructions in historic building.*



Fig.5 *Charles and Ray Eames: Eames House, California. Open system building with "off the shelf" parts.*

4.3 An open design process

Preparation for reuse often will imply that parts of the constructions will be unknown when design starts. This requires that the design process must be open, allowing a wide spectre of constructions and materials to be utilized (Fig 5 and 6). Sources of materials must be surveyed, and the "architectural tolerances" defined. Sometimes, the availability of a spectacular component may change the course of the design process.

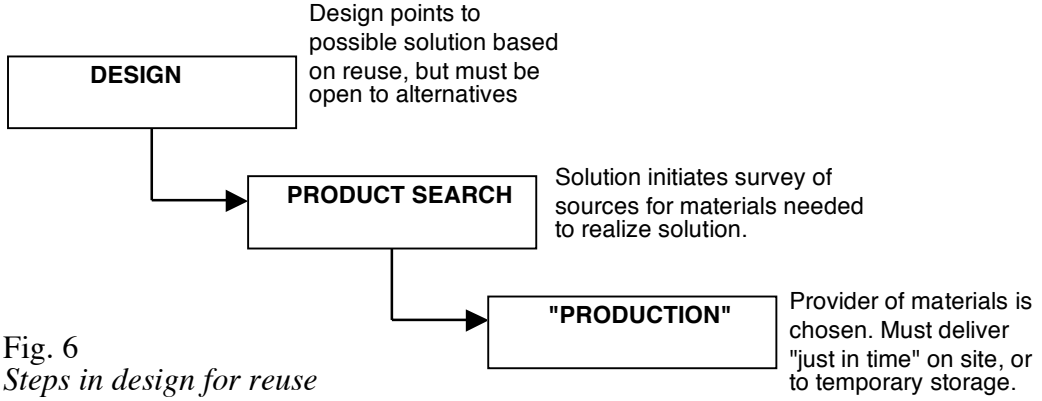


Fig. 6
Steps in design for reuse

4.4 Generality

Regularity in room forms will ease the incorporation of used components and materials. At the same time, such generality eases changes in the building´s functions over time. A combination of large, general spaces and smaller zones with a more expressive design may meet the requirements both for reuse and site-spesific articulation.

The issue of generality also relates to the design of the load-bearing structure and the HVAC systems. Bay widths should be moderate in order to incorporate different types of structures. The principle of minimum "friction" between subsystems should be applied.

4.6 Design for moderate loads

Development in building methods and building codes puts reused materials in a new setting, both technically and legally. Requirements for heat insulation and air tightness have changed. Brick is put to use in ways that expose it to heavier structural and climatic strain. The availability of materials for reuse will rise if they are used in ways that reduce such loads. For brick, this implies use in internal walls and surfaces, or in the inner parts of multi-layer facades. Windows with lower U-values may also be sufficient as an outer layer in double-skin constructions.

5. DESIGN PROPOSALS

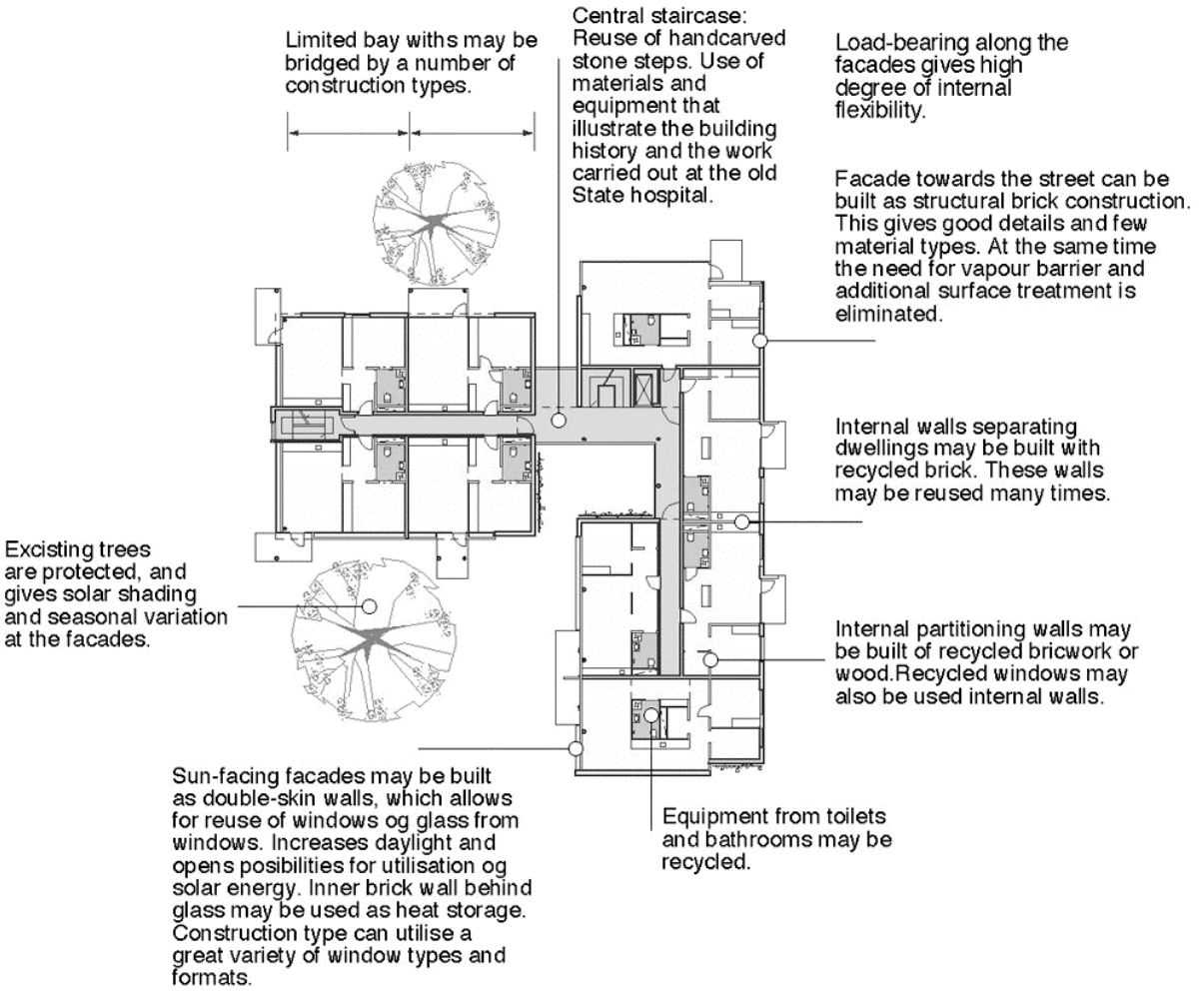
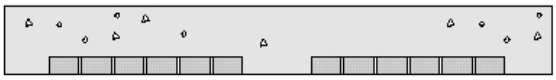


Fig. 7 *Design solutions, the Reused Building, preliminary project.*

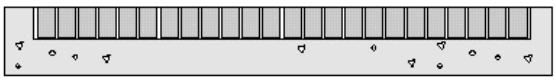
Fig. 7 shows main solutions developed during the preliminary project for the Reused Building. Many of the design strategies described in section 4 are demonstrated. A main architectural theme is the contrast between the heavy and relatively closed street facades and the double-layer glass walls facing the inner courtyard. The glass facades were planned to be assembled of reused windows in varying formats, creating a meshwork of frames interplaying with the reflected images of the large trees and adjacent facades.

Trees were accurately registred and classified. They are put to renewed use as natural sunscreens, with the shading effect matching the seasonal variations in demand for protection.

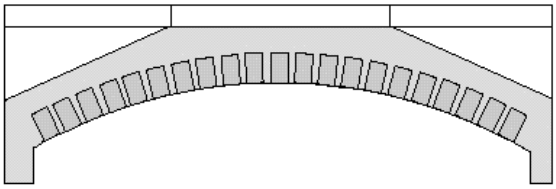
A sub-survey was made, studying reuse of brickwork. This is a common demolition resource, but often regarded as expensive because of the need for cleaning of individual bricks. Several designs were developed that utilize brick in on-site prefabricated floor and wall sections. They are shown in fig. 8.



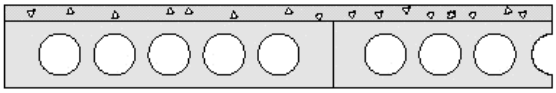
Bricwork as innfill in floor slab designed as rib construction



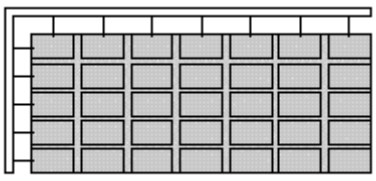
Brick used as combined infill and floor surface in concrete slab with up-turned perimeter ribs.



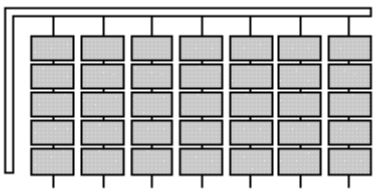
Brick infill forming ceiling in vaulted construction. Room for ductwork between vault and built-up floor.



Grinded brick used as aggregate in terrazzo-like finish on prefab. floor slabs.



Brick wall sections within steel frames



Dry-stacked brickwork hung on steel wires within steel frames

Fig. 8 *Reuse of brickwork in prefabricated floosr and walls A common feature in many of the solutions is that they allow reuse withouth thorough cleaning or processing.*

Energy efficient office buildings

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SUMMARY
The primary energy consumption of a new office building can be lowered by 70 % just by using the energy saving measures available at the market today. This is the result of a theoretical investigation carried out at the Institut Wohnen und Umwelt (IWU) at Darmstadt, Germany. But not only the environment benefits of an energy "efficient office building". An economic assessment shows that high efficient standard is even profitable. So the "efficient office building" meets both ends: the requirements of the environment an the economic interests of the investors.

TARGET AND PROCEDURE
The possibility to reduce the heating demand of dwellings by more than 80 % was shown in the year 1991 with the construction of the first passive house in Central Europe [Feist 1996], [Feist, Werner 1994]. Up to now more than 1000 passive houses were realised with success.

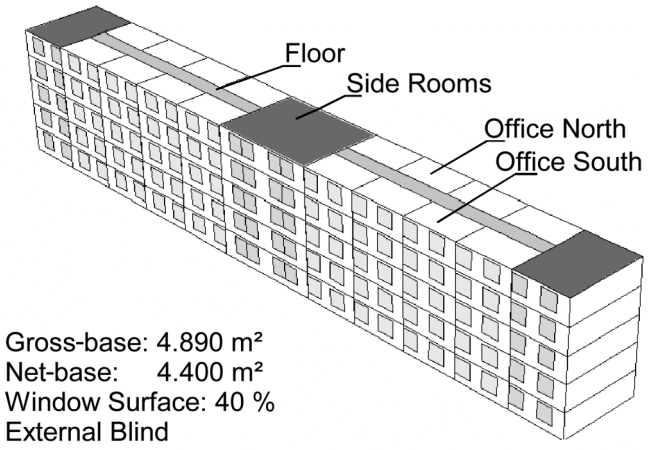

Figure 1: Outline of the examined building

In the investigation introduced here [Knissel 1999] the question was examined, whether such an efficiency increase can be realised in office and administrative buildings as well. So the energy consumption of an example building (Figure 1) was calculated for five different energetic standards. Two of the five variants are shown in the following.

1. Standard office building: The insulation corresponds to the minimum requirements of the thermal protection ordinance (Wärmeschutzverordnung) 1995. Measures to the efficient current use aren't taken up.
2. Efficient office building: It shows the best efficiency standards available at the market today.

The "efficient office building" differs from the "standard office building" in the following points:

- Very high insulation standard of the building cover
- Very low electricity consumption of the equipment and lighting
- No active cooling, humidification and dissecation
- Heat and humidity recovery and an earth tube exchanger.

The energy consumption of the variants are calculated by dynamic building simulations with the program "TAS". For the simulations the weather data of the test reference year No. 6 (Frankfurt am Main) are used as climate condition.

	Gas	electricity (mix)
Primary energy factor kWh_{Prim}/kWh_{End}	1,07	2,97

Table 1: Primary energy factors by [Gemis 3.01]

For the energetic assessment of the building both, fuel and electricity consumption, must be taken into account. This can be done by calculating the primary energy consumption. Therefore the gas and electricity consumption is multiplied with primary energy factors (Table 1). These factors were calculated by using the program Gemis (3.01).

The primary energy index is calculated by dividing the primary energy consumption by the gross base of the building. The energy index of a building consists of various single positions. To reflect the consumption structure, the single positions are divided according to the recommendations of the Swiss engineer and architects organization SIA 380/4.

PRIMARY ENERGY SAVING

For the two variants the annual primary energy requirement is calculated by using dynamic thermal simulations. The whole primary energy value of the building as well as the division on the different positions is shown in Figure 2.

By the increase of the energetic efficiency the primary energy requirement of the examined example building can be lowered from 235 kWh/(m² a) to 67 kWh/(m² a). This corresponds to a reduction of about 70 %. In the following it is briefly outlined how the savings are reached. The text concentrates on the important positions. A detailed description is found in [Knissel 1999].

Heating

The primary energy consumption for heating of the efficient office building is only 18 kWh/(m² a). Such a low value is reached by

- Insulation thickness between 30 cm to 40 cm
- Triple thermal protection glazing together with high-insulated window frames
- a ventilation plant with efficient heat recovery and an earth tube heat exchanger.

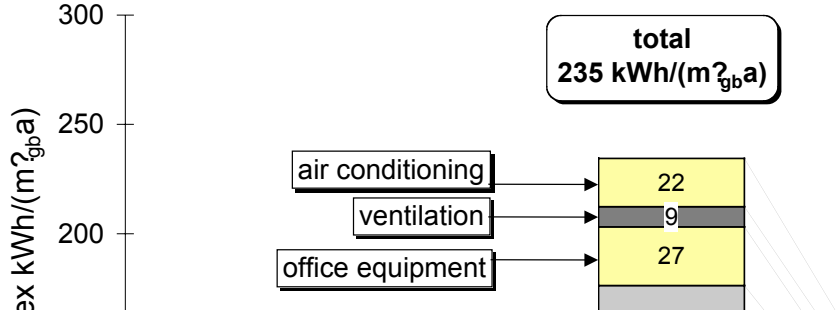

Figure 2: Primary energy index for the “standard” and the “efficient office building”

The positions “hot water”, “various technics” and “ventilation” are not discussed

Lighting

About 50 % of the total primary energy savings appear at position “lighting”. This is realised by

- high-efficient fluorescent lamps
- A lighting control, which switched off when exceeding the norm lighting intensity.
- dividing the room in zones with different lighting intensity [Hofmann 1998]. A base illumination of 220 Lux is reached by the ceiling-lamps. At the workspace 500 Lux are gained by a desk lamp.

Office equipment

By the use of the efficient equipment the primary energy consumption can be lowered from 27 kWh/(m $^2_{gb}$ a) to 4 kWh/(m $^2_{gb}$ a). In the “efficient office building” the following equipment is used:

- Notebooks as computer
- Photocopier, printer and fax with an electricity consumption of 75 % of the GED limiting values of 1998. [GED 1998]. Explanation: The community energy label Germany "GED" marks out a list of office products every year, which fulfil certain efficiency standards.

Air conditioning system

A primary energy consumption of 23 kWh/(m$^2_{gb}$ a) is required in the “standard office building” for humidification and dissecation as well as for the active cooling. In the “efficient office building” these functions can be renounced since the space comfort stays in the desired area itself. Also there is no air-conditioning system the primary energy index isn't zero since the consumption for night ventilation and free cooling is credited under this position.

The discussion points out, that no technical problems exist realising high “efficient office buildings”. All the energy-saving measures are available at the market today.
Another important question is to look at the additional costs for this high efficiency and the economy.

ECONOMIC ASSESSMENT

To assess the economy of the “efficient office building”, all payments which arise within a period of 30 years are looked at: the additional investment costs, the replacing investment after expiring the respective life time and the annual saving of energy and maintenance costs. The signs of the payments are defined as follows:

- savings: positive value,
- additional costs: negative value.

The value added tax isn't included in the payments. The assumed additional costs and savings are shown in Table 2.

Table 2: Additional costs and savings for the energy efficient office building

Additional costs and savings			Annual savings	
	€	life time		€/a
Insulation	-385.000	30	Electricity costs	26.000
Lighting	55.000	15	Gas costs	5.000
Office equipment	-160.000	5	Maintenance costs	8.000
HVAC* system	269.000	15		
Sum	**-221.000**		**Sum**	**39.000**

* Heating, Ventilation and Air Conditioning

From the discounted single payments the capital value of the investment is calculated. If the capital value is positive, the investment is profitable, if it's negative the investment is unprofitable. The boundary conditions of the economy calculation can be taken from Table 3.

Table 3: Boundary conditions of the economic assessment

Time period	30 years
Price of electricity	0,13 €/kWh
Gas price	0,022 €/kWh
Maintenance costs	2,5 % p.a. of the investment costs
Rate of inflation	2 % p.a.
Increase of energy price	2 % p.a. (nominal)
Increase of the maintenance costs	2 % p.a. (nominal)
interest rate	6 % p.a. (nominal)

Figure 3 shows the results of the economical assessment. It points out the payments calculated under these conditions for a time period of 30 years as well as the capital value of the total investment. An owner–occupied building is looked into. The owner-occupier must pay the investment costs, however the energy and maintenance cost savings also are of benefit to him. So all payments can be added to calculate the capital value.

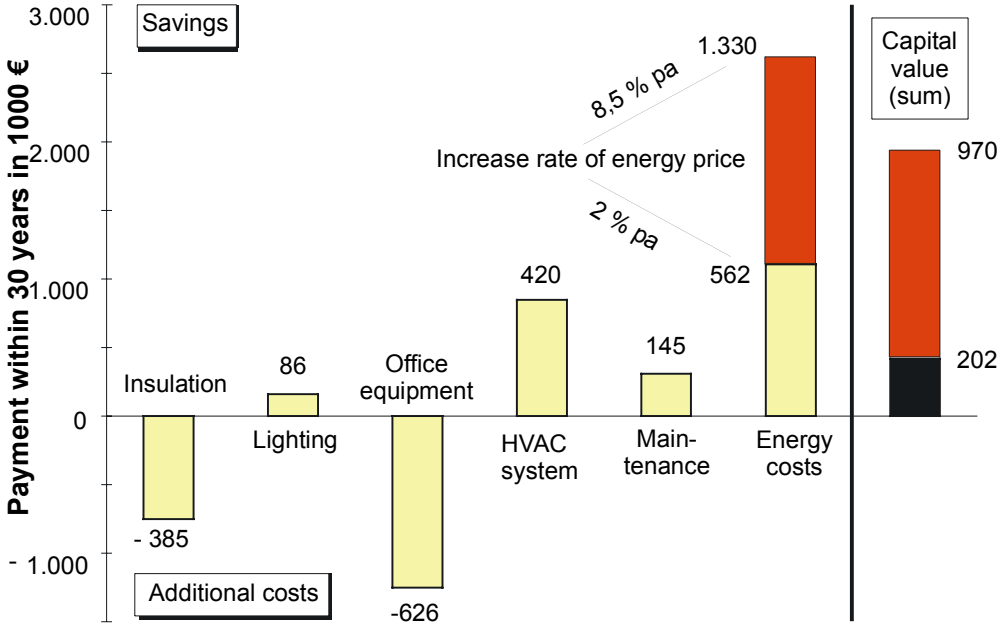

Figure 3: Additional costs and savings within 30 years for the "efficient office building"

Over the time period of 30 years the expenditures of an owner-occupier decrease. Thus it is economical for him to realise the "efficient office building" At a low energy price increase of

2 % p.a. the savings amount to 210.000 €. If the price of energy rises strongly around 8.5 % p.a., savings of 1.000.000 € show up. If the building is rented out, the same increase or decrease expenditure exists. They must however be settled by different parties or be of benefit to them.

The economical assessment points out that it is the right choice to build the office building in an high efficient standard, not only from ecological but also from economic points of view.

CONCLUSION.

Transforming these results to other projects you must consider that the primary energy savings and the capital value depend on the actual boundary conditions. Because of this the energy savings and economy must be determined individually. Nevertheless it gets clear that a high efficient standard has positive effects. It reduces the primary energy consumption and can lead to savings for the investors. The additional costs for the insulation and the efficient office equipment can be compensated by the low energy and maintenance costs and the decreasing investment costs for the lighting and the HVAC system. Because of this the high efficient option "efficient office building" should be checked for every new building.

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Sustainability Policy For A Fixed Guideway Transit System
- A Synergistic Approach

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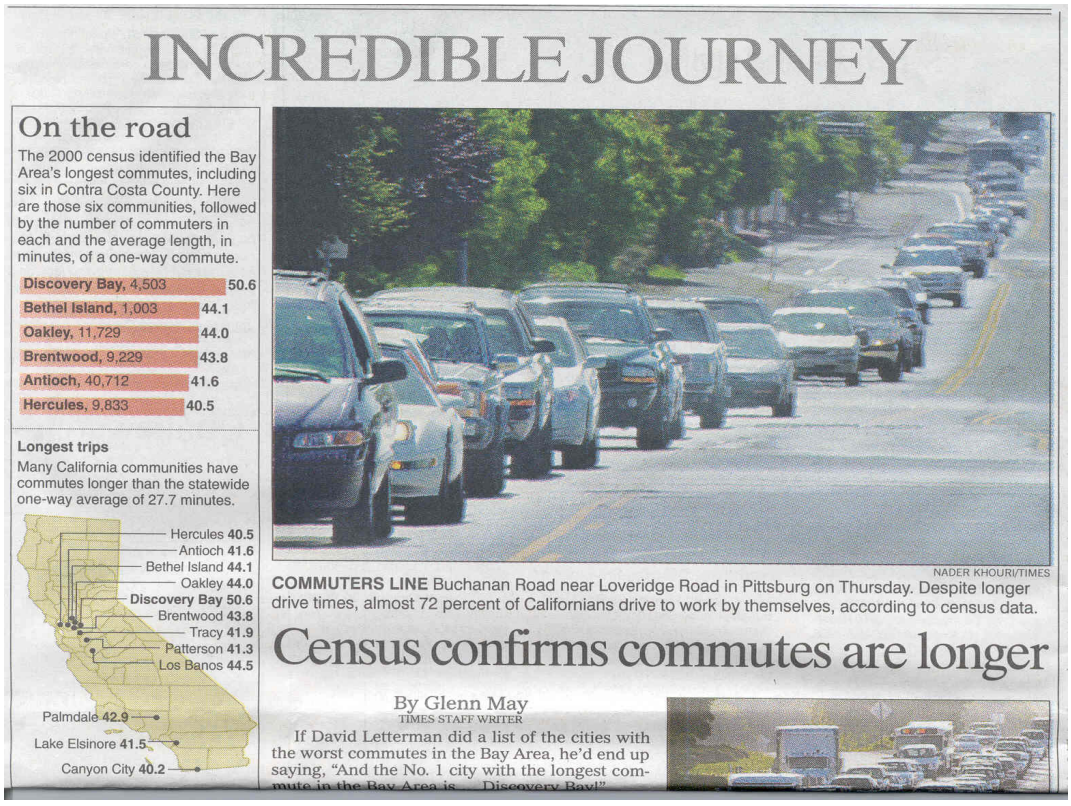
1. INTRODUCTION

Resource and environmental sustainability of a large region with core metropolitan activities requires reliable and affordable regional public transit network. An electrified fixed guideway inter-city transit system, among other public transits, is more competitive over automobiles to transport people. It can out perform automobiles in level of comfort, reliability, speed and safety.

The San Francisco Bay Area (the Bay Area) is a region with core metropolises of San Francisco and Oakland and surrounding communities exceeding one hundred municipalities. The Bay Area is a socially and geographically diverse region. The region has county-based public transit network to serve inter-city and metropolitan areas. But it has not significantly reduced automobile usage. The region still suffers classical commute traffic congestion. Figure 1 is extracted from May 19, 2002's Contra Costa Times, shows the most recent U.S. census data on inter-city commuting of the Bay Area.



INCREDIBLE JOURNEY

On the road

The 2000 census identified the Bay Area's longest commutes, including six in Contra Costa County. Here are those six communities, followed by the number of commuters in each and the average length, in minutes, of a one-way commute.

Discovery Bay, 4,503	50.6
Bethel Island, 1,003	44.1
Oakley, 11,729	44.0
Brentwood, 9,229	43.8
Antioch, 40,712	41.6
Hercules, 9,833	40.5

Longest trips

Many California communities have commutes longer than the statewide one-way average of 27.7 minutes.

NADER KHOURI/TIMES

COMMUTERS LINE Buchanan Road near Loveridge Road in Pittsburg on Thursday. Despite longer drive times, almost 72 percent of Californians drive to work by themselves, according to census data.

Census confirms commutes are longer

By Glenn May
TIMES STAFF WRITER

If David Letterman did a list of the cities with the worst commutes in the Bay Area, he'd end up saying, "And the No. 1 city with the longest commute in the Bay Area is ... Discovery Bay!"

Figure 1 US census confirms the Bay Area commutes are longer, from Contra Cost Times.
The San Francisco Bay Area Rapid Transit District (BART) is the backbone of the Bay Area's public transit network. BART is a fixed guideway transit with electrified contact rail. It operates at speed up to 80 miles per hour with service routes totaling approximately 100 miles. It directly connects 24 cities, with 16 stations serving metropolitan areas of San Francisco and Oakland. BART carries a daily ridership of approximately 300,000, majority of patrons are commuters. BART is the only inter-city and metropolitan area high-speed public transit system in the Bay Area. For the past 30 years, it has played essential role in the resource and environmental sustainability of the region. Figure 2 is BART's system map, indicating the communities that it serves.

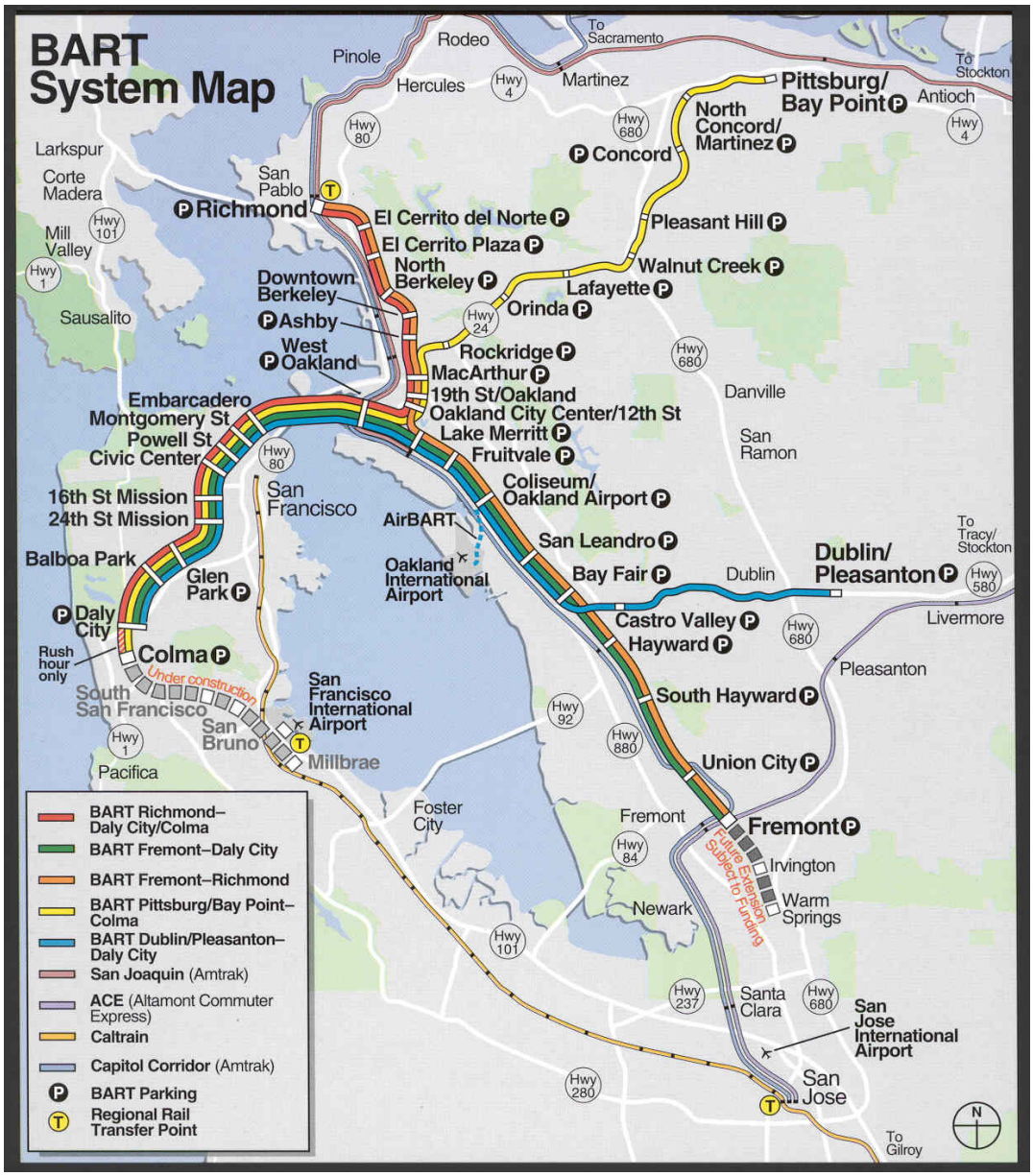


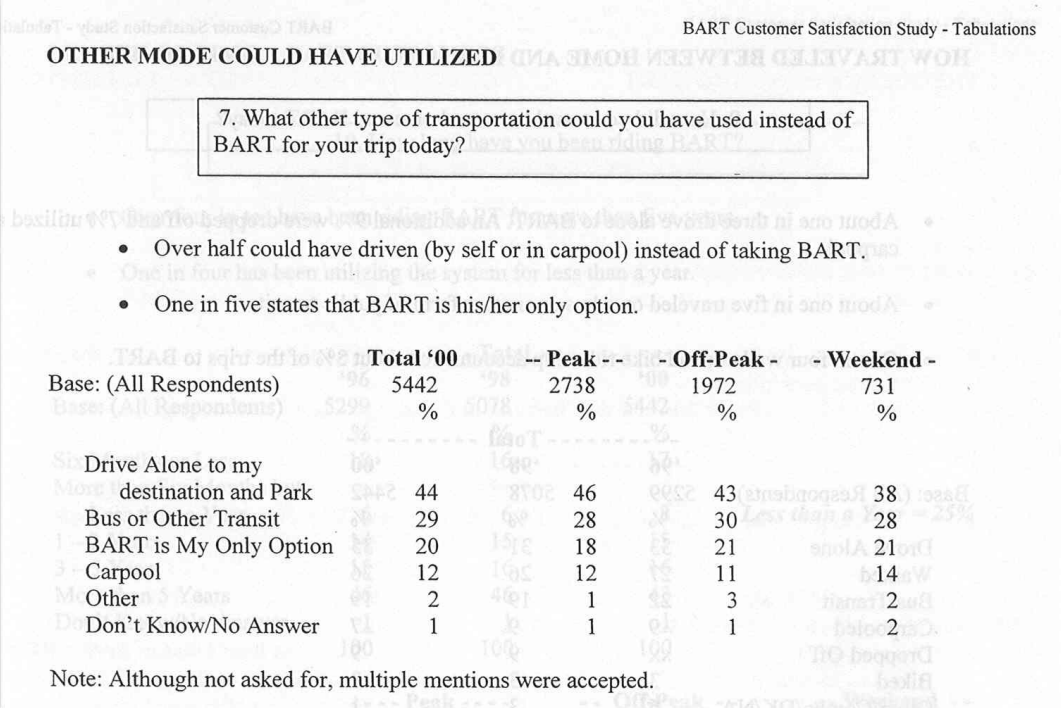
Figure 2 BART System Map, All About BART, May 2001

2. ESTABLISH CRTERIA FOR FORMULATING THE SUSTAINABILITY POLICY

When a transit system have become essential to resource and environmental sustainability of a region, the making of its sustainability policy faces at least the following challenges:

- Will the policy reinforce the transit's role in the region's sustainability?
- Will the policy enhance the quality and reliability of the transit service?
- Will the policy maintain the affordability of the transit service?
- What the policy making process will contribute to the transit industry?

Figure 3 is an extraction of BART 2000 Customer Survey. It indicated that approximately 50% BART patron would have to drive an automobile alone without BART service, and 20% patron could lose their commuting means. Such transportation displacement will severely undermine the recourse and environmental sustainability of the Bay Area.



BART Customer Satisfaction Study - Tabulations

OTHER MODE COULD HAVE UTILIZED

7. What other type of transportation could you have used instead of BART for your trip today?

- Over half could have driven (by self or in carpool) instead of taking BART.
- One in five states that BART is his/her only option.

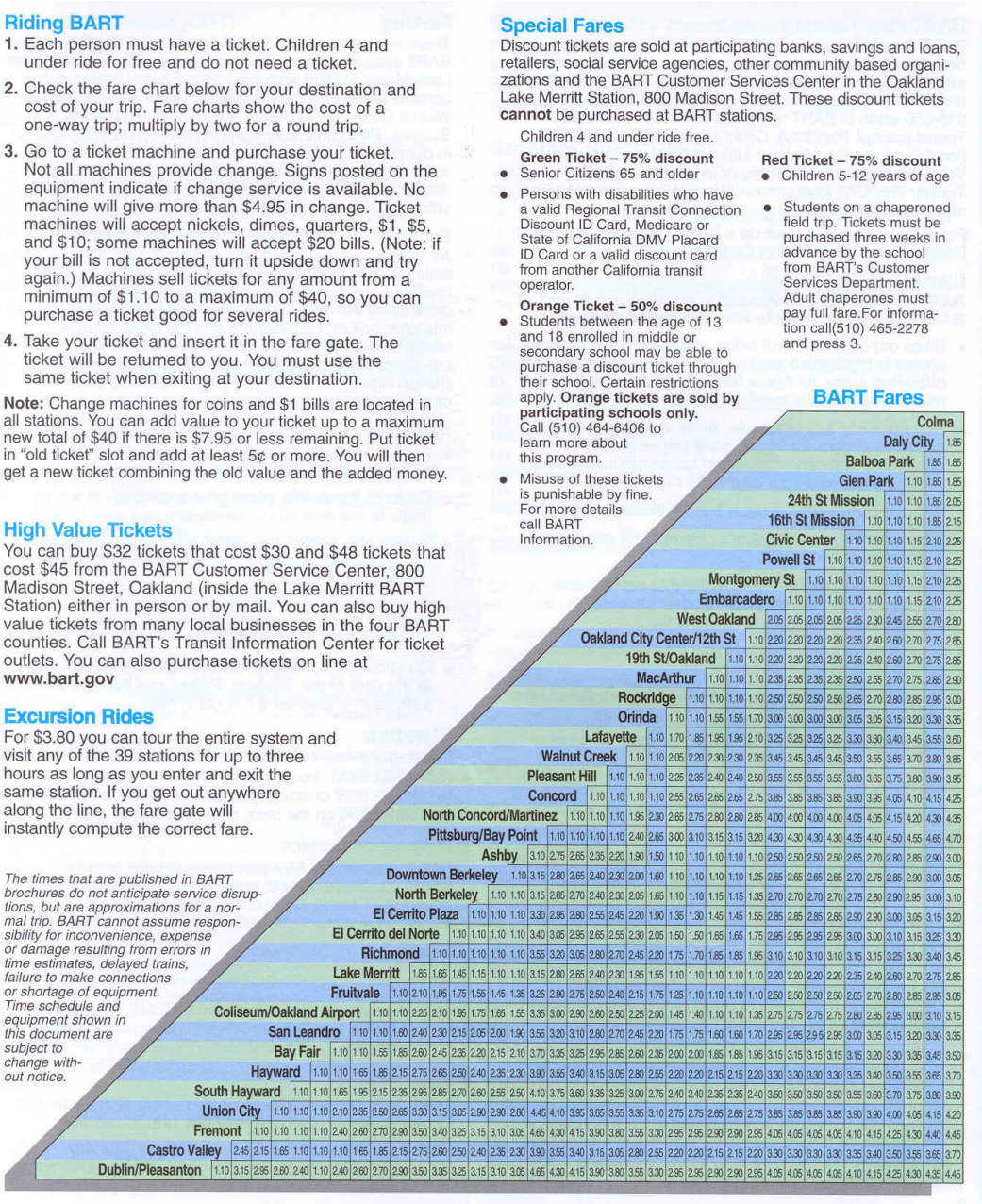
	Total '00	-- Peak - -	- Off-Peak -	- Weekend -
Base: (All Respondents)	5442	2738	1972	731
	%	%	%	%
Drive Alone to my destination and Park	44	46	43	38
Bus or Other Transit	29	28	30	28
BART is My Only Option	20	18	21	21
Carpool	12	12	11	14
Other	2	1	3	2
Don't Know/No Answer	1	1	1	2

Note: Although not asked for, multiple mentions were accepted.

Figure 3 BART Customer Survey in 2000

BART's 100-mile service routes penetrate mountains through the tunnel of East Bay hills and coast undersea through the trans-bay tube of the San Francisco Bay. BART's trackways and stations consists of aerial, at-grade and subway. BART's rail operations control system is highly automated. It requires precise coordination of high-voltage traction power and micro-electronic processors. The reliability and precisions of BART's physical infrastructure are essential for the successful transportation performance. A successful sustainability policy and implementation shall ensure or enhance the transit system's reliability.

Most public transit systems and facilities in US are supported by public funds. For example, BART is mainly funded by federal grants and county sales tax, supplemented by patrons' fares. Cost effective investment and operations will increase a transit system's life-cycle value; it will also maintain affordability to general public, both of which are keys to the sustainability of public transit. Figure 4 indicates the current BART fare schedule. BART fares are currently comparable with overall transit market value, but are expensive to some residents of the region.



Riding BART

1. Each person must have a ticket. Children 4 and under ride for free and do not need a ticket.
2. Check the fare chart below for your destination and cost of your trip. Fare charts show the cost of a one-way trip; multiply by two for a round trip.
3. Go to a ticket machine and purchase your ticket. Not all machines provide change. Signs posted on the equipment indicate if change service is available. No machine will give more than $4.95 in change. Ticket machines will accept nickels, dimes, quarters, $1, $5, and $10; some machines will accept $20 bills. (Note: if your bill is not accepted, turn it upside down and try again.) Machines sell tickets for any amount from a minimum of $1.10 to a maximum of $40, so you can purchase a ticket good for several rides.
4. Take your ticket and insert it in the fare gate. The ticket will be returned to you. You must use the same ticket when exiting at your destination.

Note: Change machines for coins and $1 bills are located in all stations. You can add value to your ticket up to a maximum new total of $40 if there is $7.95 or less remaining. Put ticket in "old ticket" slot and add at least 5¢ or more. You will then get a new ticket combining the old value and the added money.

High Value Tickets

You can buy $32 tickets that cost $30 and $48 tickets that cost $45 from the BART Customer Service Center, 800 Madison Street, Oakland (inside the Lake Merritt BART Station) either in person or by mail. You can also buy high value tickets from many local businesses in the four BART counties. Call BART's Transit Information Center for ticket outlets. You can also purchase tickets on line at **www.bart.gov**

Excursion Rides

For $3.80 you can tour the entire system and visit any of the 39 stations for up to three hours as long as you enter and exit the same station. If you get out anywhere along the line, the fare gate will instantly compute the correct fare.

The times that are published in BART brochures do not anticipate service disruptions, but are approximations for a normal trip. BART cannot assume responsibility for inconvenience, expense or damage resulting from errors in time estimates, delayed trains, failure to make connections or shortage of equipment. Time schedule and equipment shown in this document are subject to change without notice.

Special Fares

Discount tickets are sold at participating banks, savings and loans, retailers, social service agencies, other community based organizations and the BART Customer Services Center in the Oakland Lake Merritt Station, 800 Madison Street. These discount tickets **cannot** be purchased at BART stations.

Children 4 and under ride free.

Green Ticket – 75% discount

- Senior Citizens 65 and older
- Persons with disabilities who have a valid Regional Transit Connection Discount ID Card, Medicare or State of California DMV Placard ID Card or a valid discount card from another California transit operator.

Orange Ticket – 50% discount

- Students between the age of 13 and 18 enrolled in middle or secondary school may be able to purchase a discount ticket through their school. Certain restrictions apply. **Orange tickets are sold by participating schools only.** Call (510) 464-6406 to learn more about this program.
- Misuse of these tickets is punishable by fine. For more details call BART Information.

Red Ticket – 75% discount

- Children 5-12 years of age
- Students on a chaperoned field trip. Tickets must be purchased three weeks in advance by the school from BART's Customer Services Department. Adult chaperones must pay full fare.For information call(510) 465-2278 and press 3.

BART Fares

	Colma	Daly City	Balboa Park	Glen Park	24th St Mission	16th St Mission	Civic Center	Powell St	Montgomery St	Embarcadero	West Oakland	Oakland City Center/12th St	19th St/Oakland	MacArthur	Rockridge	Orinda	Lafayette	Walnut Creek	Pleasant Hill	Concord	North Concord/Martinez	Pittsburg/Bay Point	Ashby	Downtown Berkeley	North Berkeley	El Cerrito Plaza	El Cerrito del Norte	Richmond	Lake Merritt	Fruitvale	Coliseum/Oakland Airport	San Leandro	Bay Fair	Hayward	South Hayward	Union City	Fremont	Castro Valley	Dublin/Pleasanton
Daly City	1.85																																						
Balboa Park	1.85	1.85																																					
Glen Park	1.85	1.85	1.10																																				
24th St Mission	2.05	1.85	1.10	1.10																																			
16th St Mission	2.15	1.85	1.10	1.10	1.10																																		
Civic Center	2.25	2.10	1.15	1.10	1.10	1.10																																	
Powell St	2.25	2.10	1.15	1.10	1.10	1.10	1.10																																
Montgomery St	2.25	2.10	1.15	1.10	1.10	1.10	1.10	1.10																															
Embarcadero	2.25	2.10	1.15	1.10	1.10	1.10	1.10	1.10	1.10																														
West Oakland	2.80	2.70	2.55	2.45	2.30	2.25	2.05	2.05	2.05	2.05																													
Oakland City Center/12th St	2.85	2.75	2.60	2.40	2.35	2.20	2.20	2.20	2.20	2.20	1.10																												
19th St/Oakland	2.85	2.75	2.60	2.40	2.35	2.20	2.20	2.20	2.20	2.20	1.10	1.10																											
MacArthur	2.90	2.85	2.70	2.55	2.50	2.35	2.35	2.35	2.35	2.35	1.10	1.10	1.10																										
Rockridge	3.00	2.95	2.85	2.70	2.65	2.50	2.50	2.50	2.50	2.50	1.10	1.10	1.10	1.10																									
Orinda	3.35	3.30	3.20	3.15	3.05	3.00	3.00	3.00	3.00	3.00	1.10	1.10	1.10	1.10	1.10																								
Lafayette	3.60	3.55	3.45	3.45	3.30	3.25	3.25	3.25	3.25	3.25	1.70	1.85	1.95	1.95	2.10	1.55																							
Walnut Creek	3.85	3.80	3.70	3.65	3.55	3.50	3.45	3.45	3.45	3.45	2.05	2.20	2.30	2.30	2.35	2.25	1.10																						
Pleasant Hill	3.95	3.90	3.80	3.80	3.60	3.55	3.55	3.55	3.55	3.55	2.25	2.35	2.40	2.40	2.50	2.35	1.10	1.10																					
Concord	4.25	4.15	4.10	4.05	3.85	3.85	3.85	3.85	3.90	3.85	2.55	2.65	2.65	2.65	2.75	2.65	1.10	1.10	1.10																				
North Concord/Martinez	4.35	4.30	4.20	4.15	4.05	4.00	4.00	4.00	4.05	4.00	2.65	2.75	2.80	2.80	2.85	2.80	1.10	1.10	1.10	1.95																			
Pittsburg/Bay Point	4.70	4.65	4.55	4.50	4.40	4.36	4.30	4.30	4.30	4.30	3.00	3.10	3.15	3.15	3.20	3.20	1.10	1.10	1.10	2.40	2.65																		
Ashby	3.00	2.90	2.85	2.80	2.70	2.65	2.50	2.50	2.50	2.50	1.70	1.10	1.10	1.10	1.10	1.10	3.10	2.75	2.65	2.20	1.90	1.50																	
Downtown Berkeley	3.05	3.00	2.90	2.85	2.75	2.70	2.65	2.65	2.65	2.65	1.85	1.10	1.10	1.10	1.10	1.25	2.65	2.40	2.30	2.00	1.60	1.10	1.10																
North Berkeley	3.10	3.00	2.95	2.90	2.80	2.75	2.70	2.70	2.70	2.70	1.85	1.10	1.15	1.15	1.35	2.70	2.40	2.30	2.05	1.65	1.10	1.10	1.10	1.10															
El Cerrito Plaza	3.20	3.15	3.05	3.00	2.90	2.90	2.90	2.90	2.90	2.90	2.05	1.30	1.45	1.45	1.55	2.85	2.85	2.85	2.85	2.90	2.90	1.35	1.30	1.45	1.10	1.10													
El Cerrito del Norte	3.30	3.25	3.15	3.10	3.00	3.00	3.00	2.95	2.95	2.95	2.30	2.05	1.50	1.50	1.65	1.75	2.95	2.95	2.95	3.00	3.00	3.10	3.15	3.25	3.30	3.40	3.45												
Richmond	3.45	3.40	3.35	3.30	3.10	3.10	3.10	3.15	3.15	3.10	2.45	2.20	1.75	1.70	1.85	1.85	1.95	3.10	3.10	3.10	3.15	3.25	3.30	3.40	3.45	3.55	3.60	3.70											
Lake Merritt	2.85	2.85	2.80	2.70	2.70	2.65	2.60	2.40	2.40	2.20	1.95	1.55	1.10	1.10	1.10	1.10	1.10	2.20	2.20	2.20	2.35	2.40	2.60	2.70	2.75	2.85	2.90	2.95	3.05										
Fruitvale	3.05	2.95	2.80	2.85	2.65	2.70	2.70	2.50	2.50	2.50	2.40	2.15	1.75	1.25	1.10	1.10	1.10	1.10	2.50	2.50	2.50	2.65	2.70	2.80	2.85	2.95	3.00	3.10	3.15										
Coliseum/Oakland Airport	3.15	3.10	3.00	2.95	2.85	2.80	2.75	2.75	2.75	2.75	2.25	2.00	1.45	1.40	1.10	1.10	1.35	2.75	2.75	2.75	2.75	2.80	2.85	2.95	3.00	3.10	3.15	3.25	3.30	3.35									
San Leandro	3.35	3.30	3.20	3.15	3.05	3.00	2.95	2.95	2.95	2.95	2.40	2.35	1.75	1.75	1.60	1.60	1.70	2.95	2.95	2.95	3.00	3.05	3.15	3.20	3.30	3.35	3.40	3.45	3.50	3.55									
Bay Fair	3.50	3.45	3.35	3.30	3.15	3.15	3.15	3.15	3.15	3.15	2.50	2.35	2.00	2.00	1.85	1.85	1.95	3.15	3.15	3.15	3.20	3.30	3.35	3.45	3.50	3.60	3.65	3.70	3.75	3.80	3.90								
Hayward	3.70	3.65	3.55	3.50	3.35	3.40	3.30	3.30	3.30	3.30	2.60	2.40	2.20	2.20	2.15	2.15	2.20	3.30	3.30	3.30	3.35	3.40	3.50	3.55	3.65	3.70	3.75	3.80	3.85	3.90	3.95	4.00							
South Hayward	3.90	3.80	3.75	3.70	3.60	3.55	3.50	3.50	3.50	3.50	2.75	2.40	2.40	2.35	2.35	2.40	3.50	3.50	3.50	3.50	3.55	3.60	3.70	3.75	3.80	3.90	3.95	4.00	4.05	4.10	4.15	4.20	4.25						
Union City	4.20	4.15	4.05	4.05	3.90	3.90	3.85	3.85	3.85	3.85	2.95	2.65	2.65	2.65	2.75	2.85	3.85	3.85	3.85	3.90	3.90	4.00	4.05	4.15	4.20	4.30	4.35	4.40	4.45	4.50	4.55	4.60	4.65	4.70					
Fremont	4.45	4.40	4.30	4.25	4.15	4.10	4.05	4.05	4.05	4.05	3.05	2.90	2.90	2.90	2.95	3.05	4.05	4.05	4.05	4.05	4.10	4.15	4.25	4.30	4.40	4.45	4.50	4.55	4.60	4.65	4.70	4.75	4.80	4.85	4.90				
Castro Valley	3.70	3.65	3.55	3.50	3.35	3.40	3.30	3.30	3.30	3.30	2.60	2.40	2.20	2.20	2.15	2.15	2.20	3.30	3.30	3.30	3.35	3.40	3.50	3.55	3.65	3.70	3.75	3.80	3.85	3.90	3.95	4.00	4.05	4.10	4.15	4.20			
Dublin/Pleasanton	4.45	4.40	4.30	4.25	4.15	4.10	4.05	4.05	4.05	4.05	3.05	2.90	2.90	2.90	2.95	3.05	4.05	4.05	4.05	4.05	4.10	4.15	4.25	4.30	4.40	4.45	4.50	4.55	4.60	4.65	4.70	4.75	4.80	4.85	4.90	4.95	5.00	5.05	5.10

Figure 4 BART Fare Chart, All About BART, May 2001

As a part of policy-making process, BART has assessed its current position in the regional sustainability. BART uses vision statement of its sustainability policy to respond the above

outlined challenges. Figure 5 is an extraction of BART District Architect's presentation to BART management concerning the formulation of sustainability policy. It is the draft version of the vision statements of the proposed BART sustainability policy.

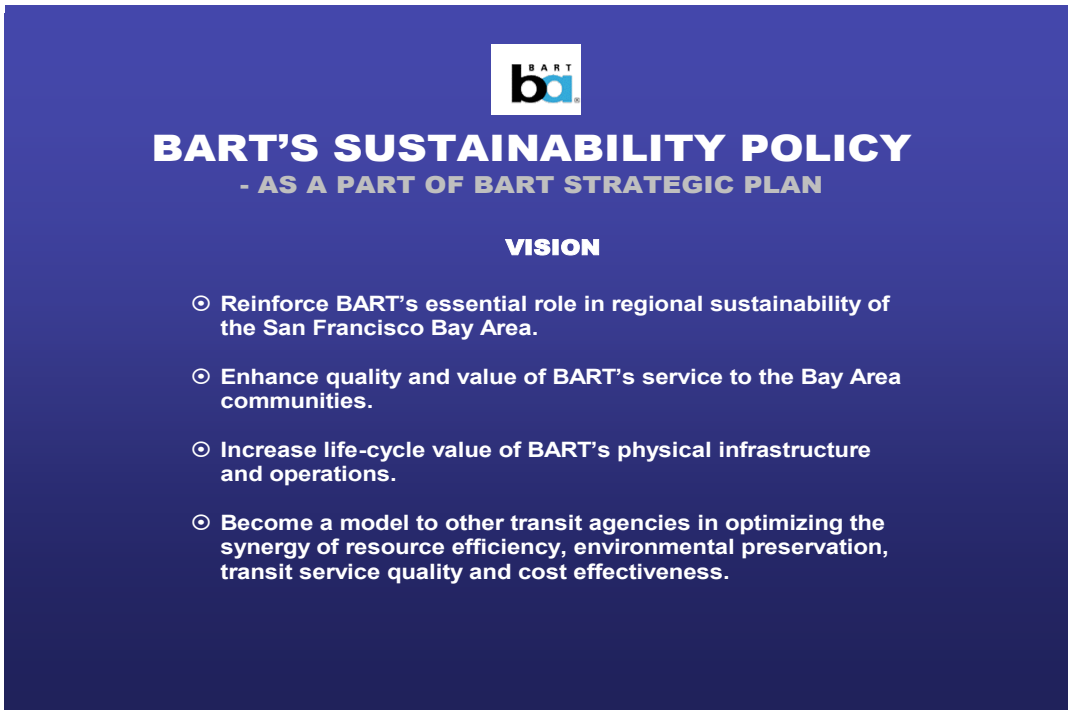


Figure 5 The vision statement of the proposed BART sustainability policy, Tian Feng, AIA, April 2002

3. IDENTIFY OBJECTIVES OF A SUSTAINABILITY POLICY

Different industries of a society play different role in sustainability based on their products and business purpose. The basic purpose of US public transit system is to provide general public with affordable accessibility and to minimize automobile impact to natural environment. A public transit can reduce automobile miles traveled and associated air emission. Consequently it reduces automobile parking spaces and roadways, therefore preserves more natural environment. It can theoretically reduce automobile usage and ownership, therefore reduces consumption of natural resource and automobile accident, which results reduction of waste and loss of productivity.

The objectives of a sustainability policy for a public transit shall reflect the purpose of a public transit system. They will at least include the following five aspects:

- Increase the transit ridership to respond the population growth.
- Reduce impact to natural environment from the transit development and enhance indoor environment for patrons and employees.
- Apply principles of sustainability to transit facilities construction and procurement.
- Establish standards for implementing sustainable materials, methods and technologies.
- Maintain the transit affordability for existing and potential riders.

It is important to research and identify technical resources suitable and adequate for formation of sustainability standard. For example BART staff, after a broad-range research, identified three resources as a part of the proposed BART sustainability standard documents. Figure 6 illustrated the three documents.



Figure 6 Three Standards identified by BART, Tian Feng, AIA, April 2002



Figure 7 A draft version of the objectives of the proposed BART sustainability policy, Tian Feng, AIA, April 2002.

4. INTEGRATE THE SYSTAINABILITY COMPONENTS

Resource efficiency and environmental preservation are the essence of sustainability in general. The public transit system responded by the nature of its business. A public transit offers the "product" - mass transportation. It also develops, constructs, maintains and operates the "manufacturing line" - transit system physical infrastructure for producing the "product". The challenge that is unique to a public transit is to optimize its sustainable performance of both.

Physical infrastructures of a public transit include a wide range of structures and buildings most of which are unconventional comparing common building and structure types. It is especially true to an electrified fixed guideway transit system. Figure 8 presents a partial list of BART facilities - physical infrastructures. Because of its unique functionality, materials, construction and operational requirements, each facility will subject to different requirements of sustainability elements.



Figure 8 BART's physical infrastructures and related sustainability elements, Tian Feng, AIA, April 2002. Information included discussions with BART Chief Engineer

BART identified 4 components as foundation for a public transit sustainability policy. They are resource conservation, service quality, environmental preservation and life-cycle cost. Figure 9 provided justifications for which the components were established.

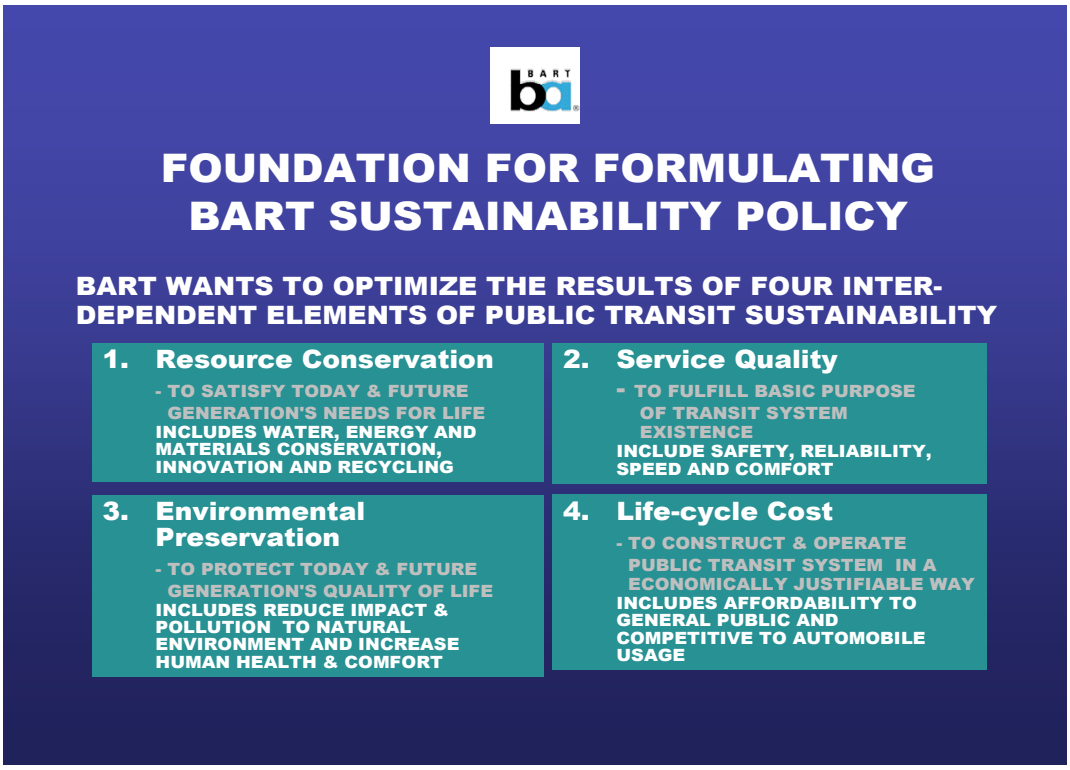


Figure 9 An illustration of 4 sustainability Components, Tian Feng, AIA, April 2002

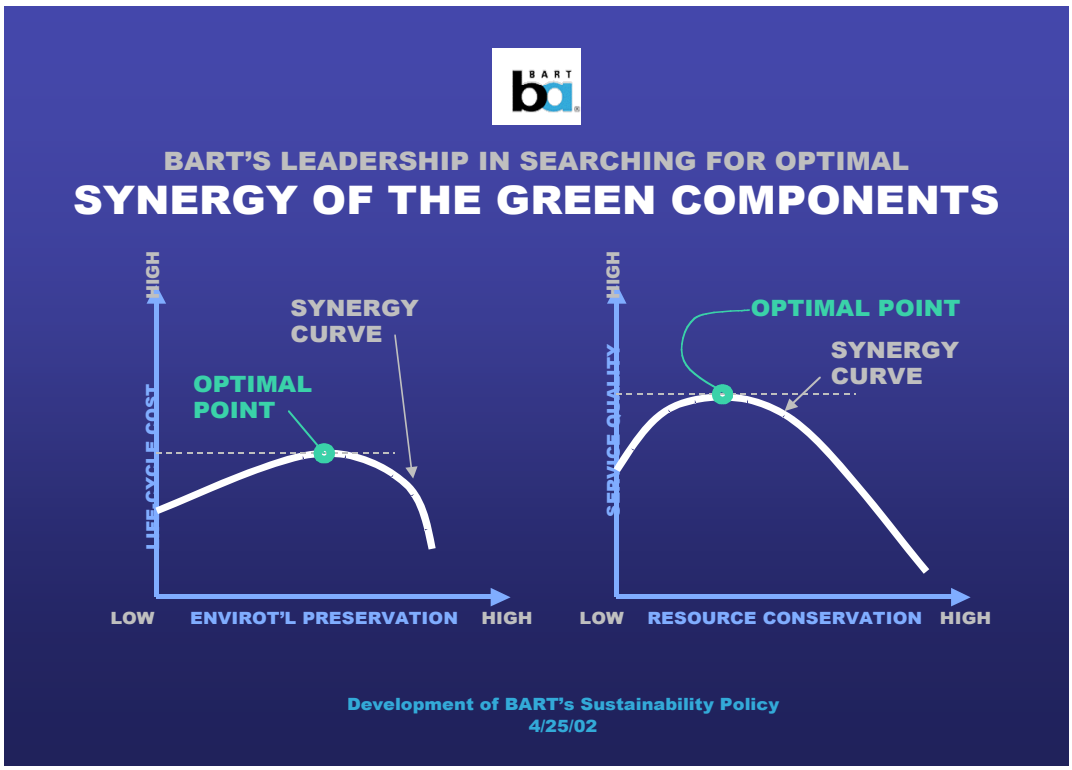


Figure 10 Synergy of 4 components for public transit sustainability, Tian Feng, AIA, April 2002.

Philosophical thinking is the key to integrate the sustainability components synergistically. To pair up the components of Service Quality with Resource Conservation will offer opportunities for search the optimal result even mathematically. For example, to field adjust an over lit parking garage by reducing electrical voltage of the circuit will conserve electricity but not degrade service quality.

Similarly, by pairing the components of Life-cycle Cost and Environmental Preservation, many planning and engineering solutions of transit development can be optimized. For example, a subway station can mitigate its impact to grade environment but will incur higher cost of both initial construction and long-term maintenance. An optimal point may not be attainable unless the planning and engineering solution is averted. Figure 10 presents a graphic explanation of the philosophy.

5. STRATEGIES TO DEVELOP, VALIDATE AND IMPLEMENT THE POLICY

When a policy affects multiple stakeholders and regulates many disciplines of works it shall be structured with commonly enforceable principles, and individualized modules that can be validated and implemented in a planned progression. Figure 11 shows examples of localized modules considered by BART staff as the strategies to develop, validate and implement its proposed sustainability policy.



Figure 11 A draft of strategies of the proposed BART sustainability policy, Tian Feng, AIA, April 2002.

6. CONCLUSION

BART is working with outside partners and inside stakeholders to solidify the proposed sustainability policy. Modifications to the proposed policy are ongoing. This paper is a summary of the policy-making approach. It is a progress report intended for information sharing at the Sustainable Building 2002. Participants of this conference are invited to offer their comments and recommendations.

BART is to assume the leadership in search for optimal performance of sustainability policy, and is to make significant contribution to the worldwide effort in promoting sustainability of public transit system.

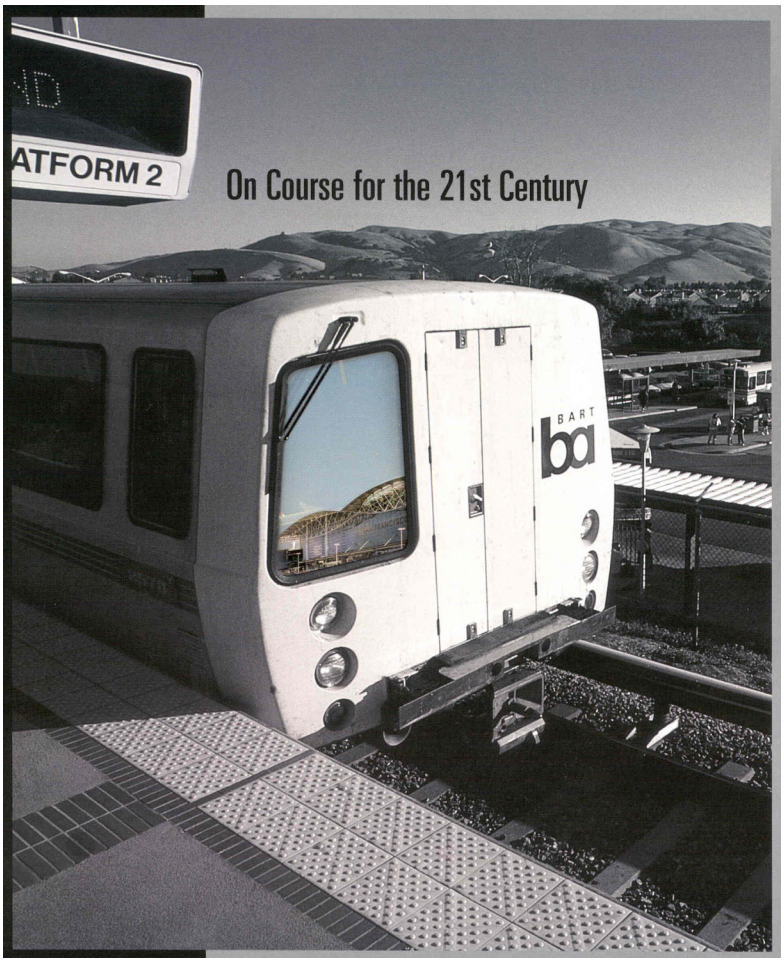


Figure - 12 BART train at a platform, BART Annual Report, 2001

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Study of current building methods that enable the dismantling of building structures and their classifications according to their ability to be reused, recycled or downcycled.

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INTRODUCTION

Waste minimisation is increasingly being adopted in the UK as one of the means to reduce the environmental impact of buildings. Waste minimisation relating to construction can involve activities during the whole building life cycle ranging from streamlining construction processes to reclaiming building components for reuse at the end of the building's life. The UK government formulated a waste hierarchy shared by academics as part of the *Waste Strategy 2000 for England and Wales* [i]. This hierarchy puts waste avoidance as the top priority to minimise waste, followed by reuse of waste, then recycling, downcycling, incineration to produce energy and finally landfilling. The hierarchy is based on the environmental benefits associated with the different waste minimisation strategies, which are:

- waste avoidance reduces the amount of waste produced:
- reusing, recycling and downcycling waste puts waste to new uses thereby helping to conserve energy [ii] and resources, reduce pollution, minimise the impact of resourcing on natural habitats and reducing waste going to landfill and the associated land use and pollution;
- incineration diverts waste from landfill and recovers some of the material's embodied energy.

At the end of a building's life, it can either be demolished or it can be dismantled and the elements and materials reused and recycled. The most environmentally beneficial use of waste is to reuse it, reuse being associated with higher reductions of embodied energy and emissions to air and water compared to recycling. [iii] However recent surveys undertaken by the Department of Environment, Transport and the Regions estimates a minimum of 53 million tonnes of construction and demolition waste being produced annually in the UK, of which 24 million tonnes of inert waste are recycled (recycled and downcycled) and only 3 million tonnes is reclaimed for reuse. [iv]

The low reuse and relatively low recycling rates reflect a number of barriers to recycling and reuse including the fact that most building elements are not currently designed for dismantling and the resulting excessive time requirements for dismantling coupled with low disposal costs make dismantling a prohibitively expensive process[v]. Demolition contractors report that deconstruction can take two to ten times longer than demolition efforts putting deconstruction at a distinct economic disadvantage.[vi] However economics is not the only barrier to reuse and recycling. Current building codes and certification systems do not generally deal with reclaimed materials and elements and where the element's performance is not a crucial issue, aesthetics and commercial desirability may be instead. Consequently even if a building material or element is capable of being dismantled from a technical and economic point of view, it still may not be reused or even recycled due to the lack of a market for uncertified products or those of lesser aesthetic appeal.

Despite the fact that most current building methods are intended for permanent installation, some building materials and elements are being reclaimed. Contractors report that reclaiming asphalt, concrete, timber, metals and historic salvaging, for recycling or reuse can represent 20 to 40% of some demolition companies' revenues[vii]. There are also some building systems that have been designed for flexibility (such as demountable office partitions), ease of installations (toilet cubicles) and even reuse (temporary buildings) and these systems are easily dismantled facilitating their reuse and recycling. Some building product manufacturers have even gone a step further and are addressing the issues of waste associated with their products by reviewing their whole business principles and integrating recycling as part of their products' life cycle. Both Interface and Milliken Carpets now offer a service to take back used carpet and recycle and recondition the carpet respectively giving them a second life. The current building industry does offer designers the products to produce buildings that can be dismantled and their building elements reused or recycled, however what is required is an assessment of which systems and products do provide these facilities and how effective they are in this respect.

The aim of this study was to develop a system to assess building products and materials for their reuse and recycling potential, which could be used to classify products and materials and facilitate the design of recyclable and reusable building systems.

DEFINITIONS

For the purpose of this study the following definitions were used:
reuse refers to when elements are minimally reprocessed and reinstalled in a building without having to be remanufactured
recycling involves complete remanufacturing to produce the same type of building element
downcycling involves complete reprocessing to produce a different and lower grade building element.

METHODOLOGY

The study selected sixty building methods and products typically used in construction in the UK and analysed their composition, installation system and durability in relation to their intended use and to the dismantling process. The building methods and products were grouped by building element type including: structural systems, external wall constructions, roof finishes, internal partitions, secondary elements, ceiling, floors and wall finishes. The building methods and products were then evaluated in terms of their suitability for reuse, recycling or downcycling using a set of criteria derived from previous research into guidelines for designing for dismantling and recycling.

The guidelines and principles for designing buildings for dismantling, reuse and recycling developed in the last five years [viii ix x xi] focus on two main areas: 1/ the process of removal of building elements and materials from building structure and 2/ the requirements for reprocessing of building elements and materials to enable reintegration in a new building.

To facilitate the removal of elements and materials from a building, these have to be designed to be technically capable to be removed with as little effort and as quickly as possible. A quick and effortless dismantling process will reduce costs of dismantling, which will then begin to compete with the cost of a standard demolition process and become more economically attractive. Effective dismantling is desirable whether the building elements are to be reused, recycled or down cycled. To achieve building designs that can be efficiently dismantled the following points should be considered.

- INFORMATION - Provide As Built drawings and Maintenance Log including identification of points of disassembly, component and material and identify materials and points of disassembly on elements.
- ACCESS - Provide easy and safe access to building element and fixings with minimal machinery requirements.
- DISMANTLING PROCESS - Simplify fixing systems and enable removal by means of small hand tools and handheld electrical tools avoiding specialist plant. Use mechanical rather than chemical fixing. Provide realistic tolerances for assembly and disassembly. Design joints and components to withstand dismantling process.
- HAZARDS - Make components sized and of a weight to suit the means of handling and provide means of handling and locating. Avoid toxic materials.
- TIME - Minimise number of parts, fixings and types of fixings and allow for parallel disassembly.

Once removed from the building, elements have to be reprocessed to enable their reuse or recycling. The nature and amount of preparation work required will depend on the characteristics of the elements and the designated use. Taking into account that reusing elements provides the greatest environmental benefits, the following recommendations aim to maximise the ability for the materials and elements to be reused, but also aim to ensure that once the element can no longer be reused it is capable of being recycled.

- REPROCESSING - Use materials that require minimal reworking, avoid non-recyclable materials such as composite materials and treatments and secondary finishes to materials that complicate reprocessing. Minimise the number of different types of components and ensure inseparable subassemblies are from the same material and components of different materials are easy to separate. Flexible installation options included.
- HAZARDS - Minimise toxic content, if toxic content is unavoidable ensure the ability to release it in a controlled manner. Make components sized and of a weight to suit the means of handling and provide means of handling and locating.
- DURABILITY - Use sturdy and avoid fragile material. Design joints and components to withstand repeated use.
- INFORMATION - Provide identification of material and component types. Provide product details and installation instructions.

The criteria derived from the above guidelines are listed in Table 1 and were used to assess materials and elements and calculate an index value to enable comparisons. The criteria are grouped to enable each element to be independently assessed for its suitability for reuse, reuse as new, recycling and downcycling. The criteria are also divided into those that assess the technical ability of materials to be reclaimed and those that assess issues affecting the cost of reclaiming materials. The criteria that assess the technical ability were given a higher weighting than those affecting the cost as the total cost will be dependant on issues other than design including location of project, labour costs etc, while the technical ability to dismantle elements is essentially dependent on the design of the building system, which may require a complete redesign if dismantling is desired.

The criteria differentiate between reuse *as new* and reuse *as second-hand product*. This addresses the issue of marketability of used building components. There is a distinct prejudice against second-hand products without historic appeal. While a Victorian fireplace will attract a respectable resale price, second-hand modern sanitary ware is very difficult to resell at all. To achieve the *as new* qualification does not necessarily involve actually appearing brand

new, achieving a suitable aged or rustic appeal will prove equally acceptable to the buying public. Where a material only achieves a standard for reuse as a second-hand product it is to be expected that its range of possible applications may be limited for certain products.

Criteria	Top rating	Bottom rating
Criteria for suitability for general dismantling		
Installation system, fixing methods	8 - Fully accessible fixings / simple installation / standard equipment required	2 – Installation precludes dismantling
Access to and handling of building elements	4 - Direct access for single person with simple equipment	1 - Specialist supports and machinery required
Hazards (toxins, structural, handling)	4 – None	1 - Special precautions/ equipment necessary
Time required to dismantle elements	4 - Low - can run in parallel to other activities	1 - Very high - dependant on other activities taking place to enable dismantling
Information required to dismantle element	4 - None required, standard installation	1 - Hazardous to dismantle without guidance
Criteria for suitability for re-use as second-hand item		
Reprocessing requirements to enable reuse	8 - Minimal, check for faults and clean	2 - Impossible to reuse
Durability	8 - Durable non-fragile element and fixings	2 - Dismantling is likely to result in damage of element
Components and sub-components	8 - Single element / no separation required	2 - Specialist machinery required to separate
Hazards	4 – None	1 - High risk / special precautions required
Requirements for performance compliance	4 - Visual test sufficient	1 - Major test regime required
Information required for reinstallation	4 - None required, standard installation	1 - Information essential to avoid hazardous installation
Fixings required for reinstallation	4 - Non-specialist interchangeable fixings	1 - Specialist non-replicable fixings
ADDITIONAL criteria for suitability for reuse as new		
Requirements to ensure aesthetic standards	4 - Aesthetics non-critical / easily achieved	1 - 'As new' aesthetic unachievable
Criteria for suitability for downcycling and recycling – assessed separately		
Reprocessing requirements	8 - Minimal preparation before reprocessing	2 - Impossible to recycle or downcycle
Durability	4 - Non-critical to recycling process / very durable	1 - Prone to disintegrate and preclude recycling
Hazards	4 - None additional	1 – Specialist protection required

Table 1 Criteria for establishing suitability for reuse / recycling / downcycling
Rating range from 4 (most suitable) to 1 (least suitable) for cost linked criteria and from 8 to 2 for technically linked criteria with a higher weighting

RESULTS

The study highlighted a number of problem areas, but also showed that there is potential for designing reusable and recyclable structures. The following aspects to consider emerged.

Interlinking elements - Building elements are interlinked as one layer of the building structure is supported on another. If the installation method of one element precludes its own reuse and recycling it is likely to also preclude the reuse or recycling of the linked elements. Wall and ceiling finishes are prime examples of this affecting the reusability and recyclability of their substrates. While mechanically fixed boarding materials (e.g. timber, plastic) can easily be removed allowing the fixings of the support structure to be accessed and ultimately enabling its dismantling, applied finishes (e.g. plaster, tiling) can make the access to the support structure fixings difficult and in some cases impossible and can also contaminate the substrate material precluding its recycling (e.g. plaster on blockwork).

Composite materials – The composite elements studied often proved easy to reuse, but impossible to recycle, confirming the guidelines produced for designing for recycling that recommend avoiding composite materials.

Materials – Different materials proved particularly suited to specific reprocessing techniques: metals being easily recycled, concrete most easily downcycled and timber easily reused.

Prefabricated elements - Prefabricated elements often rated highly in terms of their reuse potential, but some rated quite low in terms of their recycling potential as the ability to be recycled is dependant on the design of the unit itself, which often included composite material that could not be recycled or downcycled.

Certification – Reuse of such products as roof membranes, structural elements or insulation material can be hindered by the lack of certification of the elements' performance. Provision of information on the building products may partially eradicate the problem, but in certain cases testing will still be necessary adding to the cost of reusing the products. Recycling building elements circumvents the issue of product certification.

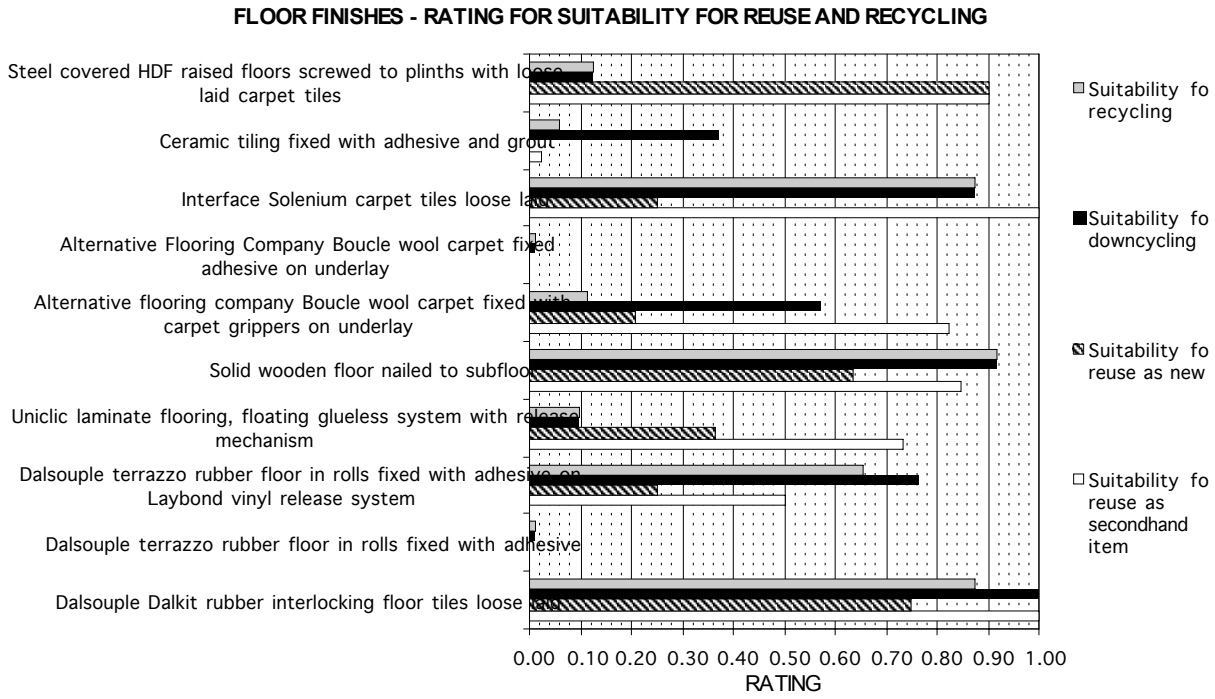

Table 2 - Graph showing rating for suitability for reuse / recycling for selected floor finishes

Aesthetics – Aesthetic barriers can hinder the reuse of building elements. This clearly applies to visible elements and perhaps applies more to internal building elements than to external building elements. The ability to reapply a finish to a product to be reused could prove invaluable in terms of reusing such items as toilet cubicles that are dismantled with extreme ease, but are normally not reused due to their second-hand appearance in a building area where a second-hand look is not considered acceptable. In particular where elements are of standard sizes, such as doors the ability to reapply a finish would make what is an easily reclaimed standard sized item very marketable. Being able to reapply a finish would also address the issue of design fashion, enabling building elements to be upgraded to the current fashion requirements.

Unit size – The reused potential of building products and elements is affected by the design flexibility afforded by the reclaimed item. Building elements made of small units such as bricks in brick walls or rubber tiles for floor finishes, allow for the units to rearranged to suit different designs. At the opposite end of the spectrum are building elements such as windows or prefabricated wall panels made of different types of units acting together as one, which if reused will dictate what the design will be. This limited flexibility constitutes a substantial barrier to their reuse.

CONCLUSION

Some areas of building design represent a particular challenge in terms of achieving easily reusable and recyclable buildings, while others already provide a good choice of recyclable products. However there is still a need to refine current designs to accelerate the dismantling process where it is already possible and enable it where it is currently impossible.

On the technical side, building finishes pose possibly the most serious technical and aesthetic problem, as the existing options that enable dismantling are not those traditionally used that appeal to the general public and the aesthetically acceptable options are often not dismantleable. As illustrated in Table 3 a commercial building designed for recycling and reuse may be in part visually indistinguishable from a traditional building designed for permanence, but a domestic building designed for recycling and would appear very unusual.

Domestic building	**Commercial building**
Concrete foundations and slab (recyclable)	Concrete frame (recyclable)
Timber frame (reusable / recyclable)	Mechanically fixed curtain walling & rainscreen stone cladding (reus./recyclable)
External walls brick cladding (reusable / recyclable)	Mechanically fixed EPDM roofing membrane / insulation (reusable./ recyclable)
Tiled roof (reusable / recyclable)	Relocatable steel and glass partitions (reusable/ recyclable)
Internal timber wall & ceiling panelling (reusable/recyclable)	Suspended metal ceiling (reusable/ recyclable)
Loose laid rubber /timber flooring (reusable / recyclable)	Raised floors (reusable) with Interface carpet tiles (recyclable)
Mermaid panels to wet areas (reusable)	Toilets cubicles (reusable) – loose laid rubber flooring (reusable/ recyclable)

Table 3 – Outline specification for reusable / recyclable building design

On a psychological level, a change of mindset is required not only in terms of aesthetics, but also in terms of adopting and promoting reuse and recycling as a truly economically viable and desirable option, not only by clients, but by all the construction industry.

Finally it is often the case that building products can be installed in a number of different ways that differently affect the product's recyclability. It is therefore through careful specification as well as considered building products selection that a dismantleable and reusable or recyclable building solution can be produced. Perhaps a model specification such as those already in use in the UK (National Building Specification), but one with the purpose of defining and specifying dismantleable, reusable and recyclable buildings would provide the most effective support for designers wanting to ensure maximum reuse and recycling.

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Life Cycle Assessment of an Elevator

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1. INTRODUCTION

Environmental impacts of buildings and construction products have been the subject of growing interest among researchers and the construction industry. Research has prompted the development of design tools, simulation models, and design guidelines for the industry to adopt environmental practices. However, little if any research is being done on the environmental impacts of elevators, specifically using Life Cycle Assessment (LCA) methodology according to the ISO 14040 standards.

An LCA study was performed to evaluate the environmental impacts of an elevator and to provide information for LCA studies of entire multi-storey buildings. The elevator studied is an energy-efficient, machine room less elevator for residential buildings. The study includes all stages from raw material acquisition to final disposal. The function of an elevator is to give people access to multi-storey buildings. Additionally, the LCA study includes sensitivity analyses and the calculation of material distribution.

2. GOAL AND SCOPE OF THE LCA

The objective of this study was to identify the environmental characteristics of an elevator and to provide basic information for environmental product declaration (EPD) and LCAs on entire building.

The function of an elevator is to give people access to multi-storey buildings. The functional unit for the study is a distance of 1km travelled by elevator. The results for a complete service lifetime are also calculated (25 years, frequency of starts 150 000 per year, average travelling height 9m).

Below are some specifics of the elevator:

Elevator:	KONE MonoSpace®
Building type:	5 floor residential building
Hoisting capacity:	8 persons (630kg) and 1.0 m/s

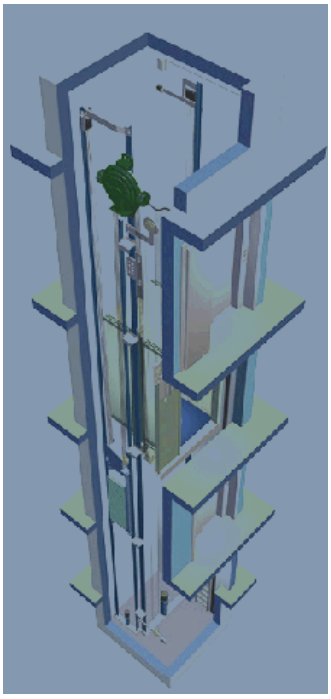

Figure 1 KONE MonoSpace®.

3. LIFE CYCLE INVENTORY ANALYSIS

Inventory analysis involves data collection and calculation procedures to quantify relevant inputs and outputs of a product system. These inputs and outputs may include the use of resources and releases into air, water and land associated with the system.

The life cycle of an elevator is divided into 8 stages: material production, component manufacturing, delivery, installation, use, maintenance, modernisation and end-of-life treatment.

Materials weighing less than 1kg were omitted from the LCA study, except for electrification components. Some materials, such as linoleum and glass, were left out because their inventories were not available. The total mass of the elevator for the life cycle inventory without packing was 2847,6kg and the omitted mass 40,2kg. Roughly 95% of the elevator materials were metals. The share of wrought steels was about 55% and cast iron 40%. The share of electronics and electromechanical components was about 5%. The elevator also included small amounts of plastics, rubber and glass. Material summary is presented in table 1.

Table 1 Material summary.

	Weight [kg]	Weight-%
Metals	**2657,8**	**93,3**
Aluminium	18,2	0,6
Cast iron	1070,0	37,6
Copper	26,4	0,9
Stainless Steel	1,0	0,0
Steel (uncoated)	979,4	34,4
Steel (zinc coated)	562,9	19,8
Plastics	**21,8**	**0,8**
Rubber	**0,6**	**0,0**
Glass	**28,0**	**1,0**
Others	**3,2**	**0,1**
Electronics and electromechanical components	**136,2**	**4,8**
TOTAL	**2847,6**	**100,0**

Components for elevators are manufactured in many different factories. The hoisting machine, for example, was manufactured in Hämeenlinna, Finland, the landing doors and the car in Pero, Italy, and the car sling, over speed governor and door operator in Scheibbs, Austria. The inventories of electrifications were calculated from EIME program results obtained from Tampere University of Technology. LCA was done for 5 floors elevator, but dividing components for floor and basic modules allows easy chancing of number of floors for the elevator.

The inventory of the delivery stage takes into account all component transportation to the logistics centre in Pero, Italy, and onward to the building site in Brussels, Belgium.

The elevator in this study was installed in Brussels. During the period of use the electricity data was taken as the average OECD value. The following assumptions were made for the period of use: lifetime of the elevator 25 years, frequency of starts 150 000 per year, energy consumption 2 000kWh per year, and average travelling height 9m. This brought the complete travelling distance of the elevator to 33 750km.

The maintenance inventory included emission from a service car with average mileage (data from Finland) and a change of ropes at the typical change interval of 10 years.

Installation and modernisation were assumed to be zero in this LCA study. The impact of installation was assessed to be low. Modernisation was left out to keep the assessment simple.

End-of-life treatment is the recycling process for multimetal scrap. Some materials have no need for a multimetal separation process, as they can be smelted at a foundry without pre-processing. The assumed amount of material requiring multimetal separation was 45% of the material weight.

3.1 Data quality, collection and calculation procedures

Table 2 Data sources.

Life cycle stage	Data sources
Material production	SimaPro 5.0 databases 1. Buwal250 2. Idemat 3. Data Archive Idemat 98 European Aluminium Association, EAA Rautaruukki Oyj Finnish Environment Institute VTT Building and Transport Neorem Magnets Oy
Component manufacturing	Data managed by KONE
Delivery	Inventories of transports from VTT Building and Transport database LIPASTO Starting and arrival places from KONE Delivery distances (km) from http://www.mapblast.com/myblast/index.mb and http://www.indo.com/cgi-bin/dist/
Installation	Data managed by KONE
Use	Data managed by KONE
Maintenance	Data managed by KONE
Modernization	Data managed by KONE
EOL Treatment	Finnish Environment Institute
Electricity	SimaPro 5.0 database: Buwal250 Eidgenössische Technishe Hochschule

LCA calculation was performed at VTT Industrial Systems with KCL-Eco 3.0 software.

3.2 Life Cycle Inventory results

The biggest releases (CO_2, NO_x, SO_x) into the atmosphere are listed in Table 3.

Table 3 Releases of CO_2, NO_x and SO_x emissions into the atmosphere during the life cycle of an elevator.

		Material production	Component manufacturing	Delivery	Use	Maintenance	EOL	TOTAL
CO_2	kg	5 129,6	1 125,3	176,1	28 075	406,4	32,0	34 944,4
CO_2	kg/ 1km	0,16	0,03	0,005	0,83	0,01	0,0009	1,04
NO_x	kg	11,5	11,9	2,2	64,5	1,0	0,3	91,4
NO_x	kg/ 1km	0,0003	0,0004	6,38E-05	0,002	3,07E-05	7,89E-06	0,003
SO_x	kg	14,3	11,3	0,019	121,3	0,5	0,03	147,5
SO_x	kg/ 1km	0,0004	0,0003	5,67E-07	0,0036	1,34E-05	9,87E-07	0,004

4. LIFE CYCLE IMPACT ASSESSMENT

The impact assessment phase of LCA is aimed at evaluating the significance of potential environmental impacts using the results of life cycle inventory analysis. The methodological and scientific framework for impact assessment is still being developed. Models for impact categories are in different stages of development. The inventory data above was converted into environmental impact using Eco-Indicator 95 and Swedish EPD methods.

Eco-Indicator is a commonly used application for life cycle impact assessment. Eco-Indicator 95 uses three kinds of factors: characterisation, normalisation and weighting factors. These scores are based on an LCA method developed by PRé in collaboration with Philips, NedCar, Océ, Schuurink and several universities (Amsterdam, Leiden and Delft) and consultancies.

The EPD method uses only characterisation factors [The Swedish Environmental Management Council 1999]. The Swedish Environmental Management Council has developed the EPD system which classifies environmental impacts in 5 categories: Global warming GWP, Acidification potential AP, Eutrophication, Ozone depletion potential ODP and Photochemical oxidants POCP.

The result of impact assessment using Eco-Indicator 95 is 65,7 ecopoints. About 81% of these ecopoints were generated during the period of use. Roughly 11% of the ecopoints are generated at the stage of material production and about 7% during component manufacturing. Emissions which cause the most ecopoints are SO_x (147,5kg) 20,9 ecopoints, Pb to water (0,09kg) 8,4 ecopoints, NO_x (91,4kg) 7,2 ecopoints and CO_2 (34 944,4kg) 6,7 ecopoints. These four emissions account for about 66% of the total ecopoints.

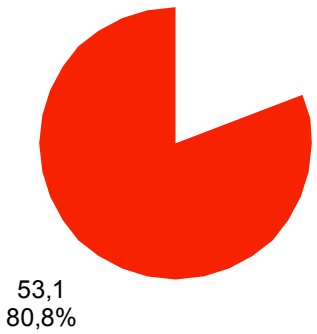

Figure 2 Life Cycle Impact Assessment using Eco-Indicator 95.

5. SENSITIVITY ANALYSES

Sensitivity analysis is a systematic procedure for investigating how reported results vary along with changes in the key assumptions on which the results are based. The objective of the sensitivity analyses was to investigate the effects on the relative importance of life cycle stages when assumptions of the lifetime of the elevator, the degree of use, the number of floors and the national electricity generation profiles were changed. The LCA study includes four sensitivity analyses.

The first sensitivity analysis was made for a lifetime of 15 years. The second sensitivity analysis concerned the frequency of starts. The LCA study (basic case) was done with 150 000 starts per year, and in this sensitivity analysis the frequency of starts were 100 000 and 200 000 per year. The third sensitivity analysis concerned the number of floors and the frequency of starts. The LCA study was done for a 5-floor elevator with 150 000 starts per year, the sensitivity analysis being for an 8-floor elevator and frequency of starts 150 000 and 200 000 per year. The fourth sensitivity analysis concerned the use of national emission profiles for the electricity generation in the country of the elevator. In the LCA study the elevator was used in Brussels but for this sensitivity analysis the elevator was in Finland, Sweden or the Netherlands.

Roughly 80% of the ecopoints were found to be induced during the period of use, except in two sensitivity analyses: when the elevator lifetime was 15 years and when the profile of Swedish electricity was used. The reasons for the smaller share of the use stage are the following: In the case of a reduced lifetime of 15 years (from 25 years), the electricity consumption was reduced by 40% and thus other stages of the life cycle have a proportionally larger impact. In the case of the Swedish electricity production mix, the use stage emissions are smaller than for the OECD average due to the large share of hydro and nuclear power (about 54% hydropower, 40% nuclear power and other about 6%).

6. CONCLUSION

The life cycle interpretation shows that most of the environmental impacts of an elevator occur during its period of use. The environmental impacts of the period of use are from the electricity production. The amount of carbon dioxide emission during the lifetime of an elevator is almost 35 tons. Roughly 80% of CO_2 emissions are generated during the use stage, as are about 71% of nitrogen oxide emissions and around 82% of sulphur oxide emissions. By comparison, during material production CO_2 emissions are 15% and during component manufacturing 3% of the total.

The LCA values of end-of-life treatment are from the recycling process for multimetal scrap. Some components have no need for a multimetal separation process, as they can be smelted at a foundry without pre-processing. The assumed amount of material requiring multimetal separation is 45% of the material weight of the elevator. When metals are recycled there is a clear reduction in environmental life cycle impacts, primarily because recycling of metals lowers the demand for primary metals as raw materials. On average, 70% scrap metal is used when producing cast iron and 20% when producing sheet steel.

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The Puget Sound Environmental Learning Center – Investing in Environmental Stewardship

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Construction Photo of PV Panels



Aerial of PSELC campus
Illustration by Stephanie Bower &
Lynn Shimamoto

PROJECT

The PSELC is an educational campus that provides young people with a deeper understanding of the natural environment through hands-on project and outdoor field experience.

The 70,000 sf, 255-acre facility is located on the south end of Bainbridge Island, Washington. The site offers a great variety of eco-systems for educational opportunities including a pond, a stream and wetlands. The educational core of the center includes the main center (interpretive center, great hall, administration), learning studios, dining hall, art studio and maintenance building. Visitor accommodations include three lodges and a guesthouse. North of the educational core is a staff housing area. Shelters, bird blinds, walkways and lookouts are featured throughout the site. The shelters and walkways are connected by a system of primary and secondary trails.

The main center, dining hall, and learning studios are targeted for Gold LEED™ certification in 2002. The PSELC was recently named one of the "2002 Top Ten Green Projects" by the United States AIA National Committee On the Environment.

Project highlights include:

SITE

- Detailed site and resource analysis mapping exercises were used to locate campus buildings for minimal impact on sensitive areas on the site.
- Southern building orientations maximize solar gain. Window sizes and locations are optimized for solar heat gain and high-energy performance. Retractable canopies lower summer heating load.

WATER

- All wastewater is treated on site to tertiary levels using either the Living Machine™ or constructed wetlands. Water from the Living Machine™ is re-used for toilets.
- Roof rainwater is collected for irrigation and for future use in toilets at visitor lodging.
- Composting toilets and waterless urinals reduce water demand.

ENERGY

- Photovoltaic installation provides over 50% of power for the learning studio building.
- Rooftop solar hot water panels reduce hot water demand at lodges and dining hall by 50%.
- Natural ventilation replaces air conditioning by using T.A.S. (Thermal Analysis System) computer modeling to locate window openings and operable skylights for maximum through-ventilation.
- High efficiency fluorescent lighting with photocells is used for energy use reduction.
- Computer monitoring of water and energy use throughout campus is used as an educational tool.

MATERIALS

- All concrete has 50% flyash substitution for cement.
- Most building materials are left untreated to reduce volatile organic compounds (VOCs) or any off-gassing that might occur due to toxicity of finishes. Durable, low VOC finishes are used throughout the Center.
- Walls are insulated with 100% recycled content cellulose.
- Over 57% of the wood products including all framing, trusses, and glu-lams are FSC Certified.
- All interior trim and 50% of siding are salvaged from site-harvested cedar, fir, alder, maple, and hemlock.



Figure 1 – Wetlands Studio


Bloedel Reserve
Bloedel Cemetery
Mac's Pond
Old Mill Road
Bloedel Cemetery
Bloedel Reserve
Agate Pass
Bloedel Reserve
Bloedel Cemetery
Old Mill Road

individual specimens. Trees removed for building sites and solar access meadows were either mulched and used on site, or milled and used for wood siding and trim. All interior trim and over 50% of siding are from site-harvested lumber.

Stormwater patterns for the site remain unchanged from pre-development conditions. Building roof water is collected for irrigation and overflow is recharged into the site's natural watershed systems.

All new landscape is comprised of native northwest species requiring no irrigation beyond initial planting and establishment. Native grasses are used in meadows to encourage wildlife habitat and provide an irrigation-free education/exploration area for students.

COMMUNITY AND CONNECTION

Formerly slated for an extensive "suburban-style" housing development, the PSELC Master Plan took a different approach to the site. All buildings are set back from property lines to eliminate any visual neighborhood impact. Only 6 acres out of 255 are used for individual building sites.

Community members, artists, teachers, and local school children were involved at early stages of the design process through a series of workshops and charrettes. Work "parties" involving these community members continued the effort by removing invasive species from the site. Numerous local craftspeople and artists were commissioned to produce environmentally sensitive furniture and artwork for the project.

Most visitors to the site arrive by bus and/or ferry. Drivers are encouraged to carpool to the site and make use of the prioritized carpool parking. Alternative fueling is provided for propane vehicles, and bike storage and shower facilities encourage alternative means of getting to work.

The city agreed to a reduced number of parking spaces contingent on the PSELC allocating land where additional spaces could be added in the future if required. Many of these spaces are crushed rock with heavy vegetation around the perimeter. If left unused, these "grow-away" spaces will slowly disappear over time.



Figure 4 – Dining Hall



Figure 5 – Main Center- Administration

LONG LIFE, LOOSE FIT

All PSELC buildings are designed for long life and low maintenance to work with the center's limited non-profit operating budget. Wood structures are set off the ground with high fly-ash content stem walls and large overhangs to protect siding from potential water damage. High quality metal roofs and metal clad windows will provide long life in the heavily wooded Northwest environment.

Primary structural systems comprised of FSC certified lumber and glu-lam trusses are bolted together with steel connections allowing members to be easily recycled and/or reused at a future date. Spaces such as the dining hall, meeting hall, learning studios, and open offices are designed to accommodate multiple uses, allowing for maximum program flexibility over time. Lodge bedrooms are equipped with bunk beds for children's programs during the week and queen-sized Murphy beds, which can be folded down for adult or family weekend program use.

Most interior materials are left unfinished and in their "natural" state. This eliminates the need for many typical maintenance routines such as painting, replacing carpeting, and repairing more fragile surfaces such as drywall. In-floor radiant heating systems combined with natural ventilation, eliminate the need for ductwork, reducing maintenance and improving air quality issues.

Energy demand at the PSELC will be reduced through active (photovoltaic, solar hot water) and passive solar systems, energy efficient lighting, daylighting, and natural ventilation.

LOW ENERGY AND HIGH PERFORMANCE

The initial energy goal for the project was to meet the LEED™ 1.0 energy credit requiring no active heating or cooling for 8 months of the year. This goal was pursued by utilizing the T.A.S. modeling discussed in the "process" section. As a result of this iterative process, a "butterfly" roof form was developed for a number of the buildings to optimize passive solar gain to the south, and still provide a large south-facing roof for solar hot water or P.V. panel installation. This section also enhances natural ventilation.

Solar meadows were created within the dense forest to allow direct sunlight into the buildings.

These meadows provide a program-required play area for children, while the felled trees were milled for siding and trim. Buildings are heated with high efficiency in-slab radiant heating systems and are cooled with operable windows, P.V. and electric powered ceiling fans.

Rooftop solar hot water systems provide 50% of annual demand at the visitor lodges and dining hall. A 23KW photovoltaic installation provides 50% of electrical loads at the learning studios. R-40 roofs and R-19 cellulose insulation walls combine with high efficiency windows to provide an efficient building envelope. All occupied rooms have daylight access and T-5 lighting with photoelectric controls.

The design process for the buildings used an interactive process of initial building envelope designs and TAS thermal analysis modeling of temperature gradients and airflow patterns to develop final building form and fenestration. The iterative design process incorporated wind, micro climate, humidity and room configurations to analyze an optimum building geometry and satisfy comfort criteria.

The challenge for the mechanical systems design team was to provide systems that would meet the comfort, health and safety expectations of staff and students while integrating high performance engineering features The reference point to meet building energy efficiency and performance for the design parameters was ASHARE/IESNA 90.1-1999 standard as well as the local energy codes. The design philosophy was to follow LEED's Bounding Comfort Parameters that allows for a wider range of temperatures than traditional design expectations. PSELC is situated in a unique environment that experiences a mild climate, strong cooling breezes and plentiful natural shade devices that can all be capitalized for savings in energy and capital costs. But there is much more to the design than just saving energy and money – the expected learning outcome for this educational facility is for students to learn about sustainable lifestyle choices through direct involvement in viewing real time energy documentation and manipulating building systems

Once the eco-mapping was completed to determine the appropriate building site, then a concentrated analysis was performed to examine optimum building orientation, shape and configuration of program requirements resulting in maximum efficiency buildings. A variety of solar strategies were incorporated into the design while accounting for the requirements of natural ventilation. Details such as strategic overhangs, shade devices and window placements optimizing passive solar strategies were integrated along with multiple sources of daylight such as clerestories and operable skylights. A photovoltaic heating system for domestic hot water was included and utility spaces utilized a photovoltaic exhaust system. These strategies provided a solution that is beneficial in both extreme seasons. During summer months solar gain is mitigated to the occupied spaces while still allowing plentiful daylight into the indoor spaces, while in winter months, the extensive daylighting remains beneficial but increased passive solar gain is attained through the strategic overhangs and window placements that capitalize on the lower sun angle

TECHNOLOGY TOOLS ENHANCE GREEN BUILDINGS

Thermal analysis simulation is a very powerful and highly technical tool that permits the design team to test many scenarios while accounting for wide-ranging variables. The use of an iterative design process involving wind, micro-climate, humidity and configurations were computer

modeled to determine the temperature gradients at regular intervals throughout the indoor spaces. By manipulating all the variables in this process as part of the computer simulation, the targeted LEED™ comfort standards could be met.

Thermal analysis is a predictive design tool that calculates the thermal response of a building over time and outputs include space temperature, space airflow, thermal profiles and energy loads. In this case the goal was to minimize the number of hours above 82F in summer and the number of hours below 65F in winter while only heating the building for 4 months of the year. During the design process, various results were confirmed including the use of 2-meter overhangs on south exposures and operable windows between south corridors and classrooms. Further performance improvements were discovered through numerous trials and experimentation such as factoring in glazings, shaded skylights and heat recovery. As part of the process, the raw data was forwarded directly to the architectural team so that results could be interpreted as a team effort.

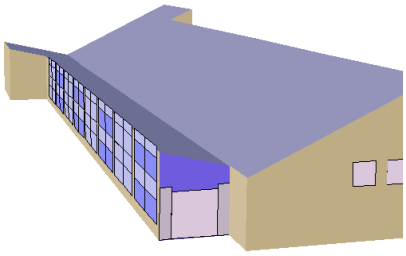

Figure 6 - Learning Studios TAS Model

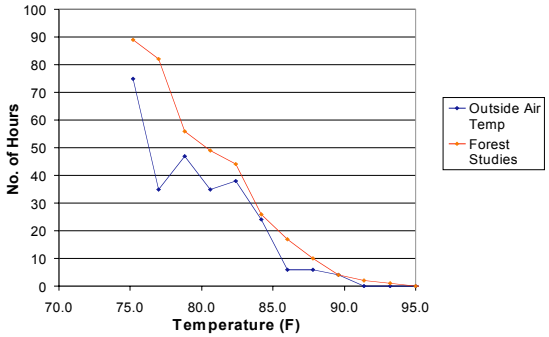

Figure 7 - Learning Studios Benchmark Results

The final result is a grouping of buildings that perform as a naturally ventilated facility with passive solar gains to offset winter loads while cooling loads are minimized for summer months and a comfortable learning environment is maintained year-round. Natural ventilation strategies include operable windows, skylights and clerestories while combining with the long thin configuration that allows for optimum crossflow and stack effect. The buildings are oriented to capture the winter sun and high performance glazing reduces cooling loads in the summer.

These techniques were used as an integral part of the overall design of this unique educational facility where classroom learning is intended to be an extension of the outdoor eco-system and it is a natural fit to utilize strategies that capitalize on local weather and natural elements. Indoor learning in the summer is very much like being in the shade and having a gentle breeze cool the space, while in winter months people benefit from maximum natural light and may require a sweater or extra layer of clothing. Certainly this is a shift from the Golden Rule of providing learning facilities with average temperatures of 72F, but PSELC embraces a complete immersion in sustainability for its visitors.

The Learning Studio building will serve as the laboratory and data collection center for the campus. Historical and real-time energy use of the different structures and photovoltaic systems

will be tracked from the Energy Sustainability Classroom. Field science data will be mapped and studied on G.I.S. systems at the Technology Center. The Wetlands Laboratory will provide equipment for visitors to study and test biological samples from the Campus' near-complete watershed.

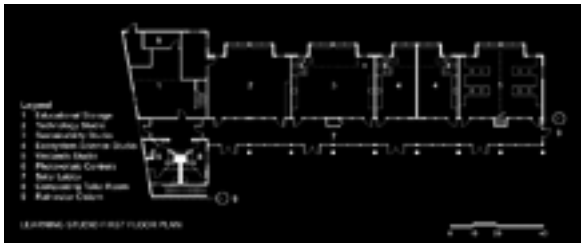

Figure 9 – Learning Studio Plan



Figure 10 – Living Machine

WATER CONSERVATION

All building wastewater is treated on-site to tertiary standards using a Living Machine™ and Subsurface Flow Constructed Wetlands. Water from the Living Machine™ is re-used for toilet flushing at the dining hall and main center bathrooms. Additionally, composting toilets and waterless urinals help reduce potable water usage at the main center, dining, and learning studios by 36% annually.

Rainwater is collected from building roofs into concrete cisterns for irrigation and boot washing. The visitor lodges will be plumbed for grey water re-use when funding becomes available.

All new landscape is comprised of native Northwest species requiring no irrigation after plant establishment. A greenhouse and exterior garden allow for the growth of native plantings for replacement of invasive species.

Students are able to monitor their water and energy usage in various buildings through an integrated computer data network. Over the course of their 4 day stay at the PSELC, they quantify and track their improvement and learn conservation strategies.

MATERIALS

The ultimate "sustainable" material is "no material at all." Working toward this goal: steel and wood roof structures are left exposed and unfinished; structural slabs-on-grade are left exposed in most areas; interior OSB shear walls serve as final wall surfaces; and drywall and paint are eliminated from all areas except bathrooms and where required by code.

Where paints, coatings, adhesives, or sealants were required, only low VOC, LEED™ compliant products were used. Over 57% of wood in the project is FSC certified. Other sustainable materials include: 50% flyash (cement replacement) concrete, 100% recycled cellulose insulation, 95% recycled content carpeting, recycled glass tiles, recycled rubber flooring, strawboard, formaldehyde-free MDF, cork, bamboo, salvaged fir flooring, recycled plastic toilet partitions, and site-salvaged wood used for trim, siding, and custom furniture.

Over 95% of construction waste (by weight) was recycled and recycling stations will be provided at each building. Food waste from the dining hall is composted and used for organic gardening. Sustainable materials are highlighted throughout project and used as part of the center's educational curriculum.

HEALTH AND HAPPINESS

All occupied spaces have direct connection to the outdoors with operable windows, operable skylights, and natural ventilation. Buildings are sited on the north side of solar meadows set against the tall trees and dense vegetation with direct views into the forest.

The mix of campus buildings is sited to create a "deep in the woods" outdoor experience, and are connected with a network of primary and secondary trails across the 255 acre site. All cars are left at the perimeter of the site, and each visitor travels through the woods prior to reaching any structures.

Long-Term Prediction of Urban Energy System and Effect of Land Use

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1. INTRODUCTION

Sustainability of urban energy system is one of the most important issues for preventing global warming and energy resource depletion. Since there are various kinds of measures for improving sustainability of urban energy system and each measure interdepends mutually, these measures must be analyzed simultaneously.

Land use in urban area is one of the other important factors that affect the availability of technological measures such as district heating and cooling, solar cell etc.

Firstly in this paper, the mutual relationship of CO_2 emission between utility side improvements and building/city side improvements is shown. Secondly, we discuss the threshold density (i.e. floor area ratio or heat demand density) for low-energy residence and DHC (district heating and cooling) system. Transition of land use pattern in Osaka city (Population: 2.6 million, Area: 220km^2) in next 100 years according to two different scenarios are simulated. Applying these results, diffusion of efficient energy systems, total energy consumption and CO_2 emission of commercial and residential sector under these land use transitions are predicted in the final part of this paper.

2. MEASURES FOR IMPROVING SUSTAINABILITY OF URBAN ENERGY SYSTEMS

Figure 1 shows the overview of urban energy systems. Though urban energy system consists of many elements, the basic concepts for improving sustainability are summarized into following four technological measures:

1) Improvement at end-use, such as improvement of energy efficiency in buildings and appliances.
2) Distributed power generation and heat supply system (including CHP and solar) inside the building.
3) District- or city-level power generation and heat supply system (including energy recovery from waste).
4) Improving efficiency and adopting renewable power source at the large-scale power generation plant outside the city.

Since the effect of one of the measures affects the others mutually, these measures must be analyzed simultaneously. Even if distributed power generation system will be popularized,

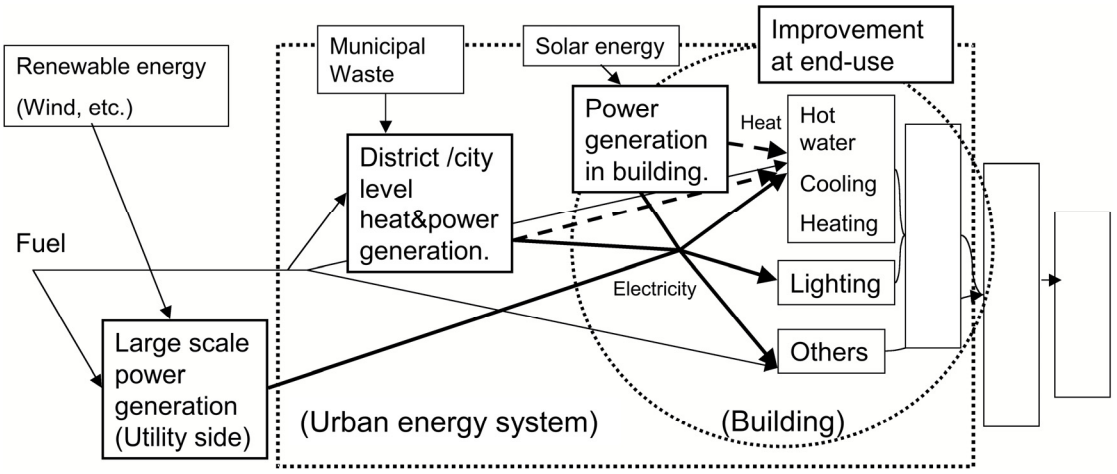


Figure 1. Overview of Urban Energy System and Technological Measures

perfect self-sufficient energy system in the city/building is supposed to be impossible. Consequently, priorities of technological measures of improving the environmental performance of urban/building energy systems are affected by the environmental performance of large-scale power supply system. Figure 2 shows the relationships between total CO_2 emission from office building (floor area: 10,000m^2) and CO_2 emission unit of large-scale power supply system under various types of urban energy system.

3. LAND USE AND AVAILABILITY OF TECHNOLOGICAL MEASURES

Land use is the important factor that affects the energy system and energy consumption in cities. So far, the relationship between land use and energy consumption is discussed mainly in the transportation sector. However, land use also affects the availability of some technological measures in the buildings mentioned above. At least, there are two examples as follows: (OECD 1995)

1) Renewable energy systems for buildings (solar cell, solar heat and passive solar house) are suitable for low-density land use, such as low-rise housing area.
2) District heating and cooling system using combined heat and power or river/sea water source heat pump are suitable for high-density land use.

To investigate the effect of land use control on improvement of urban energy system, we simulate the transition of land use (i.e. Floor area distribution of buildings in 500m square

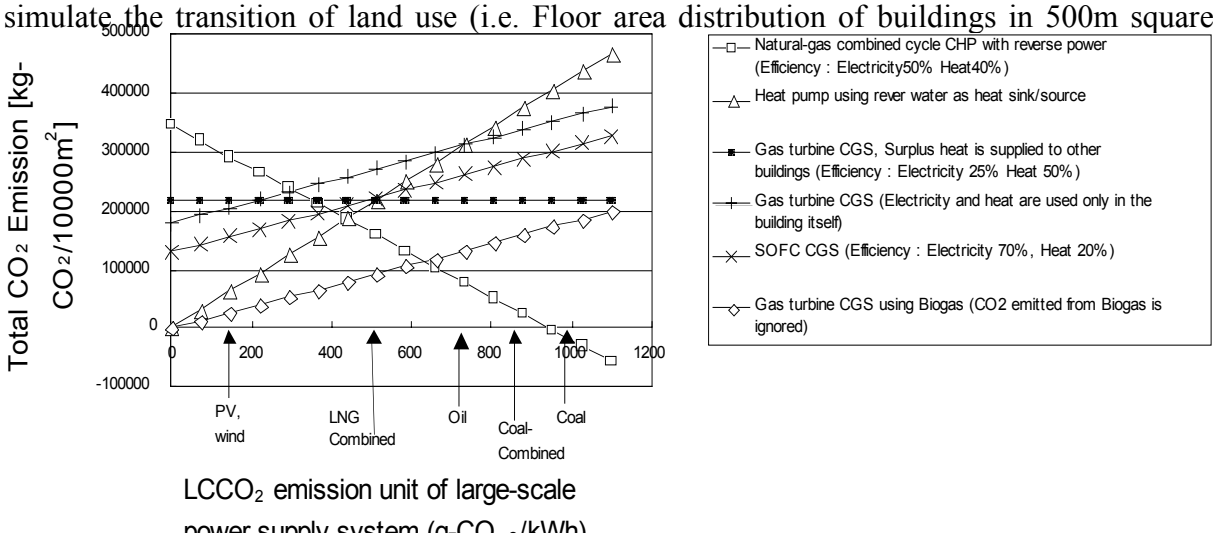
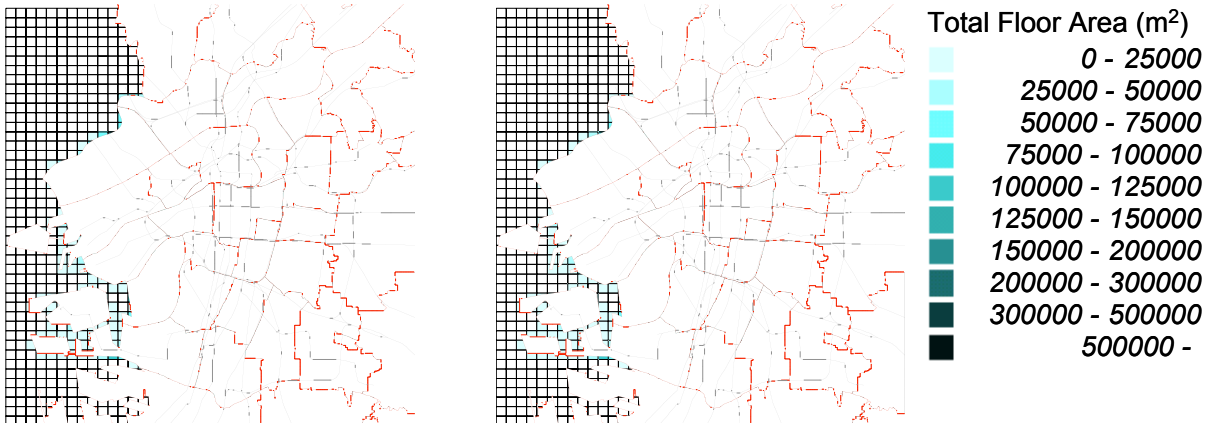


Figure 2 Relationship between CO_2 emission of building and large-scale power supply system. (Arrows in the horizontal axis show the unit of new or conventional large-scale power generators)



(1) Scenario 1 (Same as in 1995) (2) Scenario 2

Figure 3. Estimation Results of Floor Area Distribution in Osaka City in 2095

grid classified by use) in Osaka City in the next 100 years according to two different scenarios by applying cohort analysis method on buildings as follows:

Scenario 1: Business as usual

Floor area in each grid is constant in the next 100 years.

Scenario 2: Compact city with multi center

By easing floor area restriction at city center and five sub-central areas and tightening up it at surrounding area simultaneously, floor area of end-of-life buildings at surrounding area will be moved into these central areas every five years. Total floor area of each building use in Osaka City is kept constant. Figure 3 shows the distribution of floor area in 2095 depends on each scenario.

The relationship between floor area density and availability of the energy systems are supposed as follows:

1) Low energy house using renewable energy. (LEH)

In this paper, we consider solar cell as renewable energy supply system used in the low energy house. Supposing it is available at detached house with enough open space only, detached house in the grid where gross floor ratio is smaller than 40% is selected.

2) District heating and cooling system. (DHC)

In Japan, minimum heat demand density requirement for DHC is obtained empirically as 1Tcal/(ha year). However, installation of new heat pipeline into built-up area requires more strict condition. Accordingly, new district heating and cooling system is supposed to be settled at the grid where total heat demand is greater than 2Tcal/(ha year) and new additional heat demand density in 5 years exceeds 0.025Tcal/(ha year). Heat demand of each grid is estimated from floor area and heat consumption unit of each building use.

4. LONG-TERM PREDICTION OF URBAN ENEGY SYSTEM

4.1 Energy Systems Considered in This Study

4.1.1 Solar Cell. In the objective grid, the diffusion ratio of solar cell is supposed as linear function with the year (0% in 1995 and 100% in 2095). The capacity of solar cell is set to 3kW/household. The generated power substitutes power from large-scale power supply system.

4.1.2 District Heating and Cooling System. In this study, two types of heat source system are simulated separately.

(1) Natural-Gas Combined Cycle CHP Plant inside the City

All heat demand is supplied by waste heat from the power plant. Natural gas consumption and power generation is calculated monthly and efficiency of electricity generation changes according to heat demand from 30% (at 50% of heat supply efficiency) to 50% (at electricity only). The generated power substitutes power from large-scale power supply system.

(2) Heat Pump Using River Water as Heat Sink/source.

All heat demand is produced by heat pump using river water (COP_c=6.0, COP_h=4.0).

4.1.3 Energy Recovery from Municipal Waste. In Osaka City, 1.7 million ton of municipal waste is incinerated and 15,111TJ of waste heat is generated. However, only 1,214TJ is utilized at present. Therefore, it is supposed that 10% of total incineration plant is equipped with a high-efficiency power generation system and a biogas generation system in every five years. Consequently, 1,844 TJ of electricity and 868TJ of biogas is produced in the year 2045. The generated power and biogas substitute power from large-scale power supply system and city gas supply respectively.

4.2 Simulation procedure.

The simulation procedure is shown in figure 4. In the "grid loop", energy system is defined and energy consumption is calculated from the floor area in the calculation year (every five years) for every grid in Osaka City. In the "time loop", the amounts of electricity and city gas supplied from large-scale utility system are calculated by subtracting electricity and biogas production from total energy consumption in Osaka City. By supposing environmental performance of large-scale power generation system in the calculation year, total emission from the urban energy system is estimated. CO_2 is selected as the index of emission in this paper, but this simulation is possible to estimate the other pollutants.

4.3 Results

4.3.1 Energy Consumption. Figure 5 shows the simulation result of the change of primary energy consumption by residential and commercial sector in Osaka City under the land use scenario 1 (business as usual). Since floor area and heat demand density in each grid is not

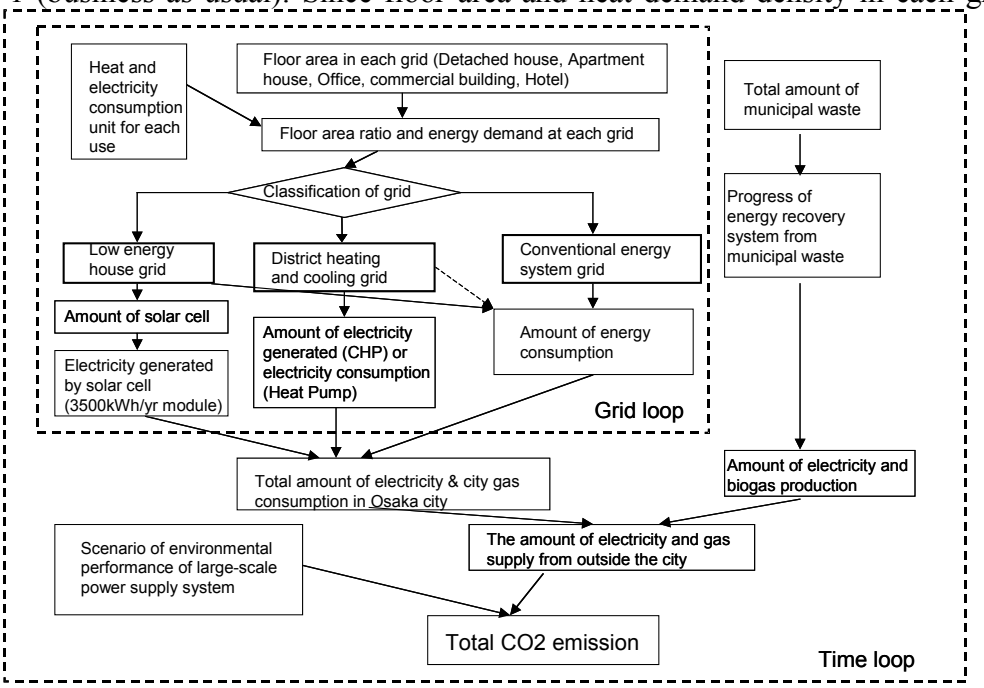


Figure 4 Procedure of simulation on urban energy system

changed in scenario 1, the grid which is introduced district heating and cooling system is not appeared. Among the 955 grids of Osaka City, 394 grids are selected as the low energy house with renewable energy (LEH) grid. Though total energy consumption in Osaka City is constant throughout 100 years, the amount of energy supplied from outside the city is decreased by 9.0% in 2095 due to increase of solar cell and energy recovery from municipal waste.

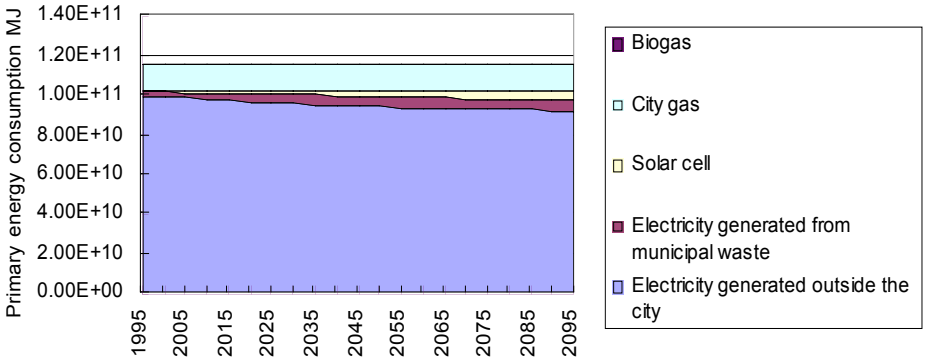
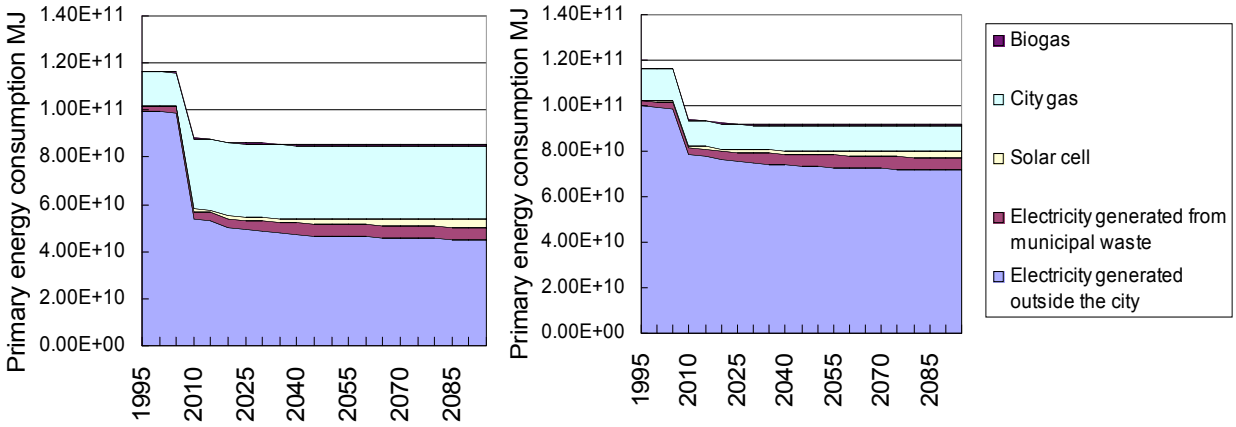


Figure 5 Change of energy consumption in Osaka City under the land use scenario 1.(BAU) (in primary energy, residential and commercial sector only)

Under the land use scenario 2 (compact city with multi center), 17 grids are selected as DHC grid and most of them are appeared in 2010. 634 grids are selected as LEH grid in 2095, but total capacity of solar cell is smaller than that in the case of scenario 1 since the total floor area in LEH grid is small. Figure 6(a) shows the change of energy consumption in the condition that natural gas combined cycle CHP system is used in the DHC grid. Since the amount of energy consumption in the city is decreased by 26.3% due to DHC system, primary energy supply from outside the city is decreased by 34.6%. Especially, the amount of electricity generated outside the city is decreased by 55.1%. If heat pump using river water is used as heat source equipment of DHC (Figure 6(b)), the amount of energy reduction in 2095 is equal to 21.2% of energy consumption in the city, 29.5% of primary energy supply from outside the city and 28.3% of electricity generated outside the city, respectively.

4.3.2 CO_2 Emission. The amount of CO_2 emission due to urban energy system is estimated



(a) Natural gas combined CHP(DHC-1) (b) Heat pump using river water(DHC-2)

Figure 6 Change of energy consumption in Osaka City under the land use scenario 2. (in primary energy, residential and commercial sector only)

under following assumption.

1) CO_2 emission unit of large-scale power supply system in 1995 is set to 0.396kg-CO_2/kWh. This means that 60% of electricity from large-scale system is produced by thermal plant (0.660kg-CO_2/kWh) and 40% of it is produced by CO_2-free power plant (Hydro, renewable, nuclear, etc.) .
2) For change of the unit due to reduction of large-scale power demand, the following two cases are examined.
   Case 1: By supposing the reduction occurred only at thermal power plant, the CO_2 emission unit is decreased by (0.660*reduction rate).
   Case 2: The CO_2 emission unit is considered as constant.
3) CO_2 emission from solar cell, electricity from municipal waste and biogas is not considered.

Figure 7 shows the change of CO_2 emission. In case 1, due to reduction of energy consumption and CO_2 emission unit, 56% of CO_2 emission is reduced in 2095 in case of land use scenario 2. There is no significant difference between CHP system and heat pump system. In case 2, reduction of CO_2 emission by heat pump system is 28% in 2095 and it is larger than the CHP system.

5. CONCLUSION

Promotion of district heating and cooling system by land use control is one of effective measures for reducing CO_2 emission from urban building energy system as well as energy recovery from municipal waste. However, the technology level of energy system (e.g. fuel cell, large-scale power system, etc.) affects the CO_2 reduction rate. Since the speed of technology development is much faster than change of land use pattern, prediction of technology level is a very important issue for long term planning of urban energy system.

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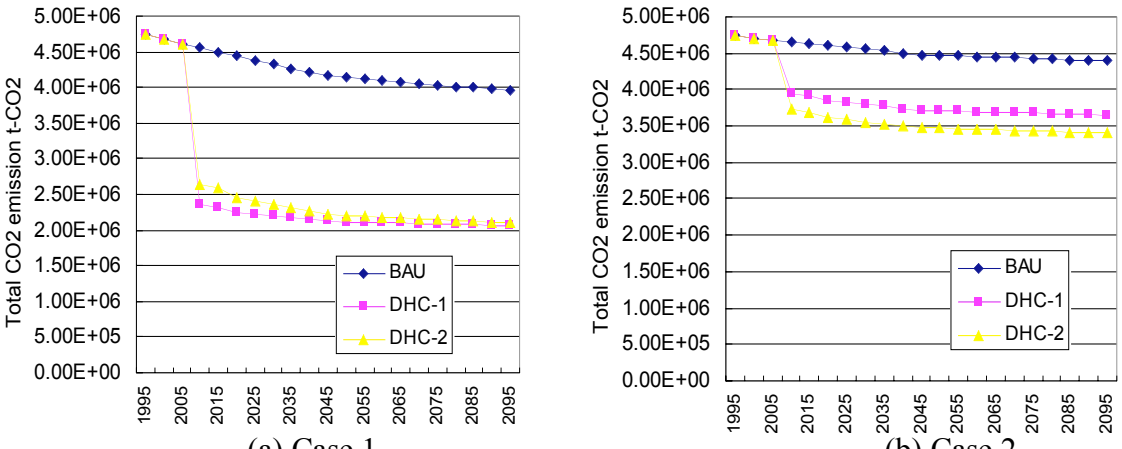

(a) Case 1 (b) Case 2

Figure 7 Changes of CO_2 emission from building energy system in Osaka City.
(BAU: land use scenario 1, DHC-1: scenario 2 with CHP, DHC-2: scenario 2 with heat pump)

Architectural Design Methodology for Tall Office Buildings Influenced by Regional Climates

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1. INTRODUCTION

1.1 Prelude

Generally, tall buildings greatly impact the scale and context of the urban environment due to their proportional mass and height, and tall buildings are a natural response to the scarcity and high cost of land and concentrated population growth. Physically, tall buildings have a concentration of built space placed on a small site area. Functionally, they enable usable floor spaces to be stacked high. In addition, growth in population and economic resources along with limited building sites and infrastructure in major business districts have motivated the rise of the construction of high-rise building to maximize the use of urban space in the big cities around the world.

On the other hand, the evolution of the mechanical system for heating, cooling and air handling systems provides for demanded comfort in a tall office building which causes higher energy demand. This situation has allowed architectural design to be free from adapting to a regional nature system.

Architects have been forced to develop design strategies for optimized design considerations based not only on low energy and low cost, but also on minimizing the environmental crisis for sustaining long-term human life. Architectural design should be concerned not only with interrelationship of space, but also with external factors such as climate.

Therefore, if human life is to be sustained in the future, it must depend on knowledge and intelligent action to preserve and enhance the natural condition by means of a harmonious rather than disruptive technology.

1.2 General Impact Factors in Architecture

The population growth and indiscrete development of technology have brought rapidly required energy consumption, and the simultaneous destruction of CO_2 diminishing forest regions of the earth. In fact, the combustion of fossil fuels since the industrial revolution has led to an excessive build-up in CO_2 and these CO_2 levels will continue to increase with the demand of energy consumption. As result of these air-polluting elements, there may be climate changes which will show various kinds of greenhouse effects and have a negative influence on the ecosystem.

1.2.1 Polices and Social Responsibility. Energy policies and social responsibility are generally related to environmental protection and renewal. As a result of the oil crisis in 1973,

many countries have adopted policies to actively improve the production and application of renewable energy systems based on an economical purpose. Lim (1999) mentioned that this effort to actively promote energy efficient systems may first come from governments that initiate taxation incentives, introduce energy regulations and codes of practice and promote renewable energy. And, it may be generated by the individual who becomes aware of his of her social responsibility in environmental protection and renewal. Therefore, the polices or rules from governments may be a desirable way to control and promote energy consumption patterns. Economic viability and social acceptance are also equally significant opportunities to achieve a low energy/sustaining world in the future.

1.2.2 Population Growth. Large population growth may accelerate the depletion of energy resources because of the demanded increased energy consumption, and then it will have a negative impact on the global environmental systems and human ecosystem. Shea (1988) mentioned that in developing countries, if the population of these countries doubles as expected, their required commercial energy would increase 7.5 times from 1980 to 2020, and the increment in energy consumption would be 1.3 times the world's total energy usage in 1980.

1.2.3 Lack of Commitment towards Energy Use. Generally, architects and other designers have not considered the climate as a defining inevitable design factor in the modern age after the industrial era. This contrasts with pre-industrial architecture with a unique society and culture without high technology, and with an architectural design that responded to the regional climate conditions. After the rapid evolution of technology, architects tended to depend on available technology to solve the local constraints problem. This attitude generally accepted an architecture that did not consider the local natural system (weaken local characteristics), but buildings were designed to maintain human comfort by technology which, in turn, created an environmental problem because of higher energy consumption to support mechanical systems in a building.

1.3 The Target of the Study

This study seeks to make a contribution to the development of the design methodology for tall office buildings in relation to regional climate conditions as a resource for architects during the early phases of the design process. The primary aim of this study is to evaluate design factors of a tall office building based on climate conditions by means of measurement of annual energy consumption of a building. It will indicate the consistency of the interrelationship between design factors for a tall office building and regional climate characteristics.

1.4 The Methodology of the Study

To evaluate design factors with climates, this research uses the hypothetical building model based on the measurement of basic design strategies in practice. The model assists the architects in determining external design considerations: building form, window sizes on façades, and building layout in respect to regional climate characteristics at the early stage of the design process. The building model as an experimental study is evaluated by means of computer simulation as the tool for experiments to achieve comparative analysis between the model to be considered and regional climates in the study. This research uses the eQUEST program based on DOE 2.2, and it will be utilized to obtain the expected data between design considerations and energy performance to measure annual energy consumptions in relation to regional climate conditions. This study will develop an integrated method of building design

and planning by incorporating heating, cooling and lighting based on sequence of computer simulations in respect to different climate conditions.

2. APPROACH AND DEVELOPMENT OF A FUNDAMENTAL CONCEPT

2.1 Approach to Ecological Design in Architecture

Ecological design means a partnership with nature for the long-term all species on the earth and it clearly approaches the design dimension of the environmental crisis. Ryn (1996) described the integrated design concept implies that respects species diversity, minimizes non-renewable resources depletion, preserves nutrient and water cycle, maintains habitat quality, and attends to all the other preconditions of human and ecosystem health. Therefore, the considering ecological concept as the basis of any design can contribute to diminish the environmental negative impacts. The decreasing destructive environmental impacts can explicitly increase positive harmony between human and nature.

2.2 The Concept of Compromising Energy Performance on a Building

The energy design of an architectural environment to achieve an optimum human comfort can conceptually into divided by a relationship between an architecture designed with nature and one with engineering control (designing with artificial technology). The end result generally provides an occupant's comfort in a space that is sensitive to the global environmental and the issues of artificial energy generation and consumption. (Figure 1)

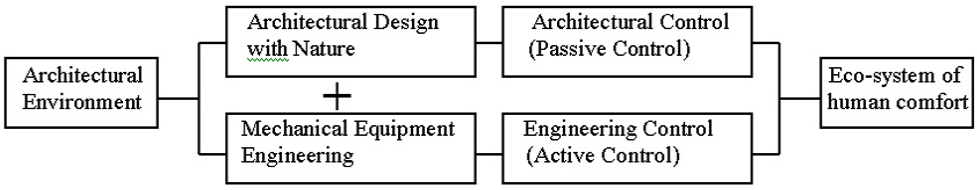


Figure 1 The composition of architectural environment

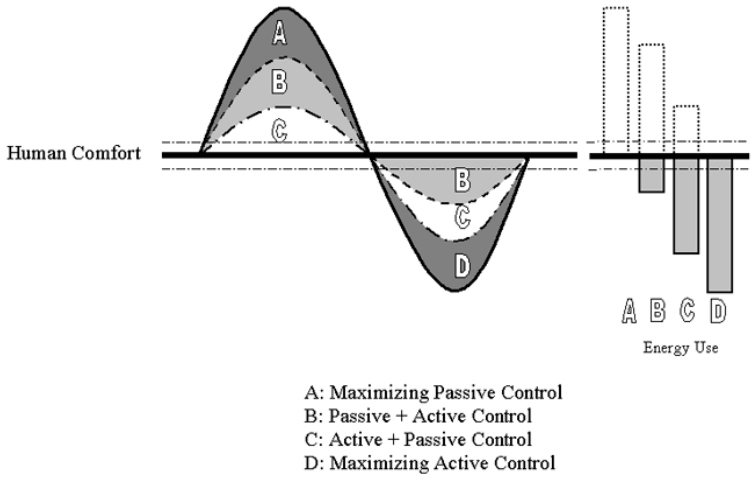


Figure 2 The relationship between passive control and active control

Conceptually, there should be an increasing portion of architectural designing with nature (passive) and a decreasing portion of engineering (active) to maintain the desired human comfort in a tall office building. The relationship between both factors is ideally an inverse proportion. Therefore, a performance of maximizing passive control for human comfort in a

space can achieve not only minimizing active control, but also minimizing the environmental consumption as a positive result for sustaining long-term human life. (Figure 2)

3. CONSTRUCTION OF HYPOTHETICAL MODEL FOR THE RESEARCH

3.1 Architectural Considerations. Table 1 shows the architectural considerations.

Table 1 The assumption of architectural considerations for model

Factors	Assumptions
Building gross area	2,166,000 square feet
Building typical floor area	36,100 square feet
Number of floors	60
Percent of occupied area	70%
Percent of core area	30%
Lease span depth	45 feet
Ceiling height	9 feet
Floor to floor height	13 feet
Windows	Double insulating ¼ in + ½ in + ¼ in
Walls	Aluminum(uncoloured) exterior finish
Core	Utility center core system
Function	Office with open plan
Considered building forms	Square, Rectangle (1:1.8 floor ratio), Triangle, and Octagon
Considered orientations	South, South-East, East, North-East, North, North-West, West, South-West

3.2 Engineering Considerations. Table 2 shows the engineering considerations.

Table 2 The assumption of engineering considerations for model

Factors	Assumptions
HVAC system	Standard variable air volume system with electric zone reheat, Return air pass by duct, Electric resistance for heating, Chilled water coils for cooling (Chiller type: electric centrifugal hermetic)
Occupancy schedule	9:00am to 6:00pm, Monday through Friday
Space requirement	150 sqft per person
Indoor thermal	72 ^{o}F for heating set point, 75 ^{o}F for cooling point
Indoor lighting	50fc for ambient lighting level, Lighting control type: continuous
Indoor ventilation	20cfm per person for outdoor air requirement in typical space

3.3 Others Considerations. Other considerations are as follows:

- Climate zones selected based on four different climatic conditions in the United States: cool, temperate, hot-arid, and hot-humid
- Considered regions selected by four cities in the United States according to climate zones: Chicago/cool, New York/temperate, Phoenix/hot-arid, Miami/hot-humid
- The total annual energy consumption of modelled buildings used for quantitative analysis
- Output data for energy use in buildings indicated as kWh

4. RESULTS OF COMPARATIVE ANALYSIS

The study explores the integrated energy use characteristics of the design relationship among building forms, window sizes, and building orientations according to different regional climates as follows: (Orientation is constructed as shown in Table 3.)

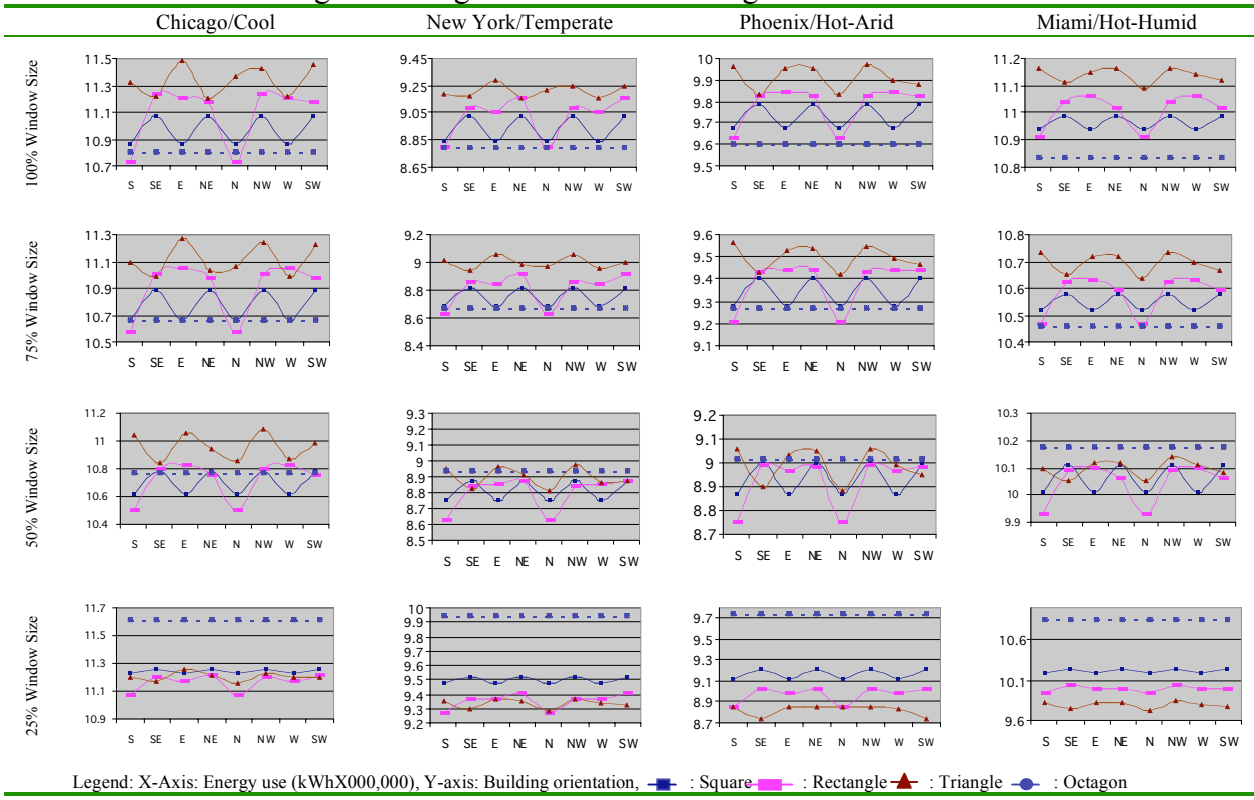
- Southern layout buildings generally result in lower energy consumption than other considered orientations.
- Compared to the orientation with eight directions depending on climates, the building orientation implication for the square and the rectangular forms would be that buildings with a more southern exposure perform better than those with a more eastern exposure. Even though a southern exposure receives more heat gain and natural daylighting in winter; both east and west facades receive as much solar radiation in summer. The rectangular form generally has lower energy consumption than the square form on a southern exposure, but the arithmetical mean of energy use for the square form is lower than the rectangular form on the other orientations with the mean value for all climates.
- The rectangular form results in higher energy consumption on north-east or south-west layout than on a southern layout and the building orientation implication could be that the south-east or the north-east are better than the east layout for all climates.
- The triangular form generally results in a lower energy consumption on the south-east, north and west layouts. On the other hand, the south, east, and north-west layouts of the triangular form use higher energy for all climates. In addition, the south-west layout of the triangular form uses higher energy in the cooler climate, but this is reversed in a hotter climate.
- The design for octagonal form in tall office buildings can be advantageous with larger window size in all climates. The energy variation according to window glazing variation for the octagonal form is bigger than other considered forms for all climates.
- When looked at results individually, heating and cooling factor variations have an important effect upon total energy in all climates according to different orientations. The lighting variation according to orientation is slight.
- When looked at results synthetically, the harmonic design determination of tall office buildings improves the reduction of the total energy requirement for heating, cooling, and lighting as much as 19.3% to 27.1% in disregard of the offset effect between thermal and lighting performance according to regional climates (Chicago: 19.3%, New York: 27.1%, Phoenix: 26.6%, Miami: 24%).
- The integrated information to determine tall office design based on the relationship among building forms, window sizes, and building orientations is shown in Table 4.

Table 3 Configuration of Building Orientation

	South	South-East	East	North-East	North	North-West	West	South-West
Direction								
Square								
Rectangle								
Triangle								
								

Octagon

Table 4 The integrated design information with regional climates



5. CONCLUSION

As a result of the previous comparison of architectural design consideration for tall office buildings in relation to regional climates, buildings physically need less energy consumption when the architecture is concerned with the regional climate and it produces a more reasonable design methodology. In reality, imbalanced planning which is architectural design's lack of regional characteristics requires additional natural resources to maintain desired comfortable indoor conditions. Therefore, the application of integrated architectural design with regional nature should be the first architectural design stage and this research produces the rational. This architectural design language approach must be a starting point to sustaining long-term planning.

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The incentive Role of a regional environmental Agency - Arene Ile de France – in developing Eco-building (HQE) Projects

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The Regional Agency for the Environment and New Energies (ARENE) of the Paris Region was created in 1994 and is supported by the Regional Council of Ile-de-France. Its mission is to improve quality of life for the inhabitants of the Paris Region (population of 12 million) by making it easier for the relevant economic, social, and cultural players to incorporate the issues of the environment, of renewable energies, and of energy savings into the regional sustainable development programmes that they are currently drafting. ARENE is a tool for implementing sustainable development on a regional level, and it conducts territorial action in seven fields:

- energy savings and renewable energies;
- industry and the environment;
- employment and the environment;
- local Agenda 21;
- clean transport;
- environment-focused education; and
- HQE ("Haute Qualité Environnementale" - high environmental quality or eco-building).

Such action involves:

- supporting reproducible pilot projects;
- providing expertise and practical assistance;
- promoting exemplary actions; and
- leading networks of participants.

ARENE assisted the Regional Council with the first implementation in France of the "HQE" approach to building a secondary school, the “Lycée Maximilien Perret” (architect Maximiliano Fuksas), in Alfortville in 1997.

The "HQE" approach focuses on criteria for reducing consumption of natural resources and discharge of pollutants, as well as for enhancing the comfort and the health conditions of buildings. It concerns especially the design and the construction phases both of refurbishment projects and of new building projects.

To promote this approach among public authorities (county ("département") councils, municipalities ("communes"), social housing landlords) or private contracting authorities (banks, companies, developers), ARENE proposes innovative tools in the fields of technical assistance, of networking and training of key players :

- “Conseil Express HQE:” free advice related to an HQE building; and

- "Info Plus HQE:" one-day programme for heightening awareness of the HQE approach.

ARENE provides also forecast surveys to promote eco-building projects : like

"HQE challenges for 2010 in the Ile-de-France Region":
The aim of that survey was to present the overall reduction in environmental impacts, the economic benefits on energy, waste, water, and greenhouse gas emission, and the job creation that would result from individual eco-building initiatives spreading in the period leading up to 2010.

For this purpose, 11 sectors and 7 environmental themes were examined both for new building and for refurbishment:

Sectors	*Themes*	*Aspects considered*
Housing - individual housing - social housing - private collective housing Tertiary - offices - secondary schools - primary and infant/nursery schools - health - gymnasiums - swimming pools - canteens -	**energy**	Consumption **(**heating, hot water, lighting / natural lighting , specific electricity), Contribution to reducing the greenhouse effect
	water	Consumption of drinking water Rainwater harvesting
	maintenance	Cost of operating the building
	building site	**Building waste** **Noise pollution** generated by the building site; **Occupational accidents**
	noise and comfort	**Acoustic comfort**
	materials	Wood
	OVERALL COST OF OPERATION	

Two development scenarios:
- an approach driven by strong political will: 100 % of the new construction or refurbishment operations between 1999 and 2010; and
- a more gradual "going with the flow" approach taking account of the commitments already made, and of the growing awareness of the players, with the following hypotheses:
  - 100% of the new and refurbished "lycées" (high schools/sixth form colleges) by 2006;
  - 70 to 80% of new or refurbished secondary schools and indoor swimming pools, and of new primary and infant/nursery schools by 2010;
  - 20% to 40% of new or refurbished sports establishments and social housing, and of refurbished primary and infant/nursery schools by 2010; and
  - 3 to 15% for new or refurbished offices, individual and collective private housing, healthcare establishments, and canteens by 2010.

As regards methodology, the survey firstly calculated energy and water consumption, and maintenance costs per major sector of buildings for 1999 in the Ile-de-France Region.

Secondly, working hypotheses were adopted concerning the unit consumption and spending for a building of the eco-building (HQE) type, compared with a conventional reference building.

Using this database, the survey was then able to explore two types of results:
- the total cost of an HQE operation with the cost per metric ton of carbon avoided, as calculated for each standard building of each of the sectors; and
- the consolidated impacts of generalising the HQE approach throughout Ile-de-France in 2010 in terms of overall savings in energy, in water, and in site management…

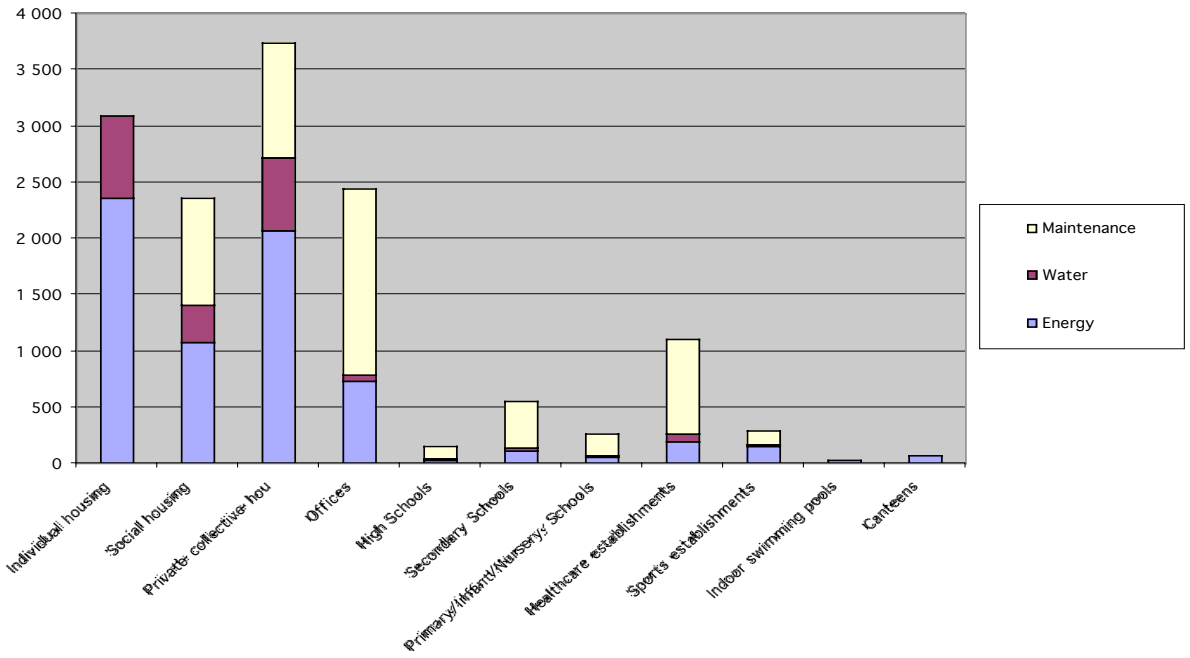
The impacts of HQE (eco-building) for the Ile-de-France Region in 2010 using the will-driven scenario

- 30% energy savings in the residential and tertiary sectors;
- 40% of the target for reduction of national greenhouse gas emissions, converted to regional level, i.e. 1.6 million tons of carbon avoided;
- 16% drinking water savings for the sectors surveyed (100 million cubic metres per year);
- a saving of 228 euros per year and per capita on the operating costs and maintenance costs for the buildings of the 11 sectors in the survey, i.e. as much as the annual budget of the Regional Council of Ile-de-France;
- savings on building waste management through sorting and selective demolition;
- greater use of recyclable materials and of renewable raw materials, such as wood;
- a reduction in the noise levels in housing, with 60,000 fewer people complaining about noise;
- a reduction in occupational accidents on building sites through quality approaches;
- 40,000 direct or indirect jobs generated for the building work and the infrastructure and fittings work, the average extra cost of HQE investment being 49 euros per square metre built or refurbished;
- average savings (net of depreciation) of 2.3 to 4.6 euros per year and per square metre built or refurbished; and
- overall, net savings (5% updated) of 8.2 billion euros over 15 years for an HQE investment for the period 2001-2010 of 17.5 billion euros.

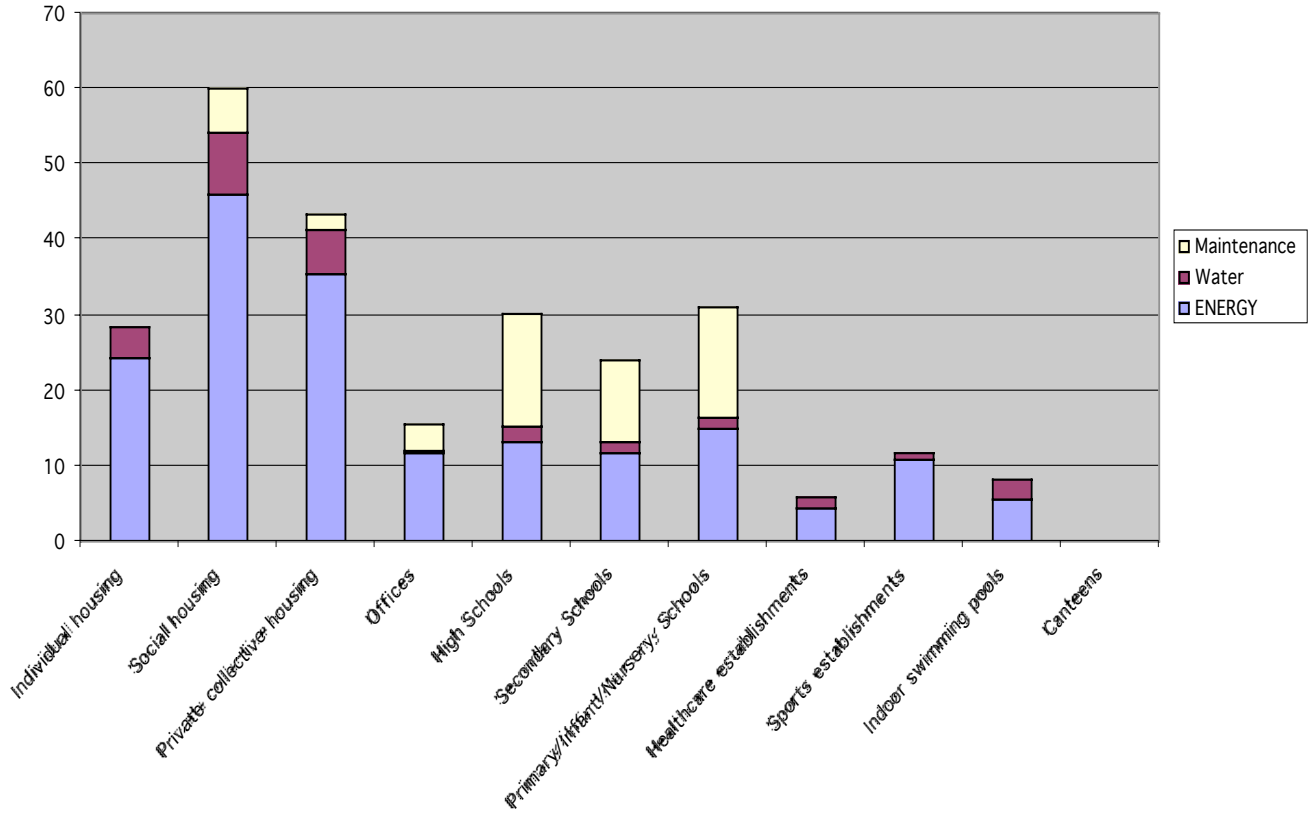
The gradual "going with the flow" approach would make it possible to achieve only 10% of these potential savings. The largest percentage savings can be expected from teaching establishments, but in terms of volume, housing is the most promising sector for overall savings.

In all, the operating or usage savings for a building can reach 6.1 to 9.15 euros per square metre built or refurbished per year.
Such savings represent, for example, 8 to 10% of the cost of a social (subsidised low-rent) dwelling (rent + service charges): HQE could offer its occupants one month's holiday from rent per year!

Regional spending in millions euros by sectors



"going with the flow" scenario : total operating savings in million euros in 2010



Ten reasons for promoting the "HQE" (eco-building) approach.

1 Savings for users and improved comfort (noise, health).

2 Overall costs that are lower for a usage value of the buildings that is higher.

3 Savings in non-renewable resources (energy generated from fossil fuels, water, raw materials, …)

4 New or additional economic activity, and therefore jobs.

5 An increase in the qualification of companies through internal management effects.

6 A social redistribution policy: HQE in social housing will improve the quality of life and comfort of the least-privileged inhabitants, without increasing their rents.

7 The contribution to combating the greenhouse effect: from 2.7 to 5.3 kg of carbon per square metre built or refurbished.

8 In schools, a unique occasion for environment education, in particular for HQE refurbishment projects.

9 Increased partnership between the town/city and building professionals.

10 Integrating urban regeneration policies and environment policies into projects for refurbishing neighbourhoods or projects for urban redevelopment.

Examples of free services proposed by the ARENE

- **"Conseil Express HQE"** (free advice on high environmental quality) :
technical assistance for local authorities or private investors in designing new or refurbishment projects with the aim of incorporating HQE principles into the building. This service, proposed and paid for in full by ARENE, assigns 3 experts to the contracting authority for one half day to give their opinions to it: an architect, a heat engineer and an economist demonstrate the feasibility of the eco-building project and the importance of environmental management system procedures. After the oral presentation, a written report:
    - summarises recommendations on the possible theme priorities (environmental target aspects - eco-design, eco-management, comfort and health) to cover in the project; and
    - describes the tangible steps for a successful eco-building project (e.g. overall cost approach taking account both of the maintenance and operation phases, and of investment).

  This service helps the beneficiaries significantly in launching their eco-building projects on good foundations.

  In all, ARENE provided 30 such "conseil express HQE" advice services in 2001 to local authorities, in particular for projects for schools, sports facilities, social housing… but also to private investors (research centres, hotels, business nurseries…). After hearing the team of experts, almost all of the contracting authorities decided to continue their project with an HQE approach, by making provision for the human and financial resources necessary to succeeding with such a project. The most decisive element often lies in good management of the operation as regards environmental

management, and in consultation between the various players involved in all of the phases: local authorities, design team, engineering and design offices, construction firms, future users…
In 2002, 30 new actions are planned for a variety of contracting authorities.

- **"Info Plus HQE":**
- a day for heightening HQE awareness with a presentation of best practices proposed to the technicians and the politicians in several municipalities of the Region. The awareness day is led by a specialist on environmental approaches to building, also with testimonies from other professionals. The programme for the day is set in close co-operation with the contracting authority. In addition to the description of the usual 14 targets of the HQE approach with the environmental management system, it proposes "à la carte" modules concerning specific topics of interest for the targeted group (10-20 persons): local Agenda 21 and spatial planning related to building operations, sports and leisure facilities, maintenance of social housing…

Conclusion of the incentive role of the ARENE

By providing awareness-heightening and information tools to the various contracting authorities in the Region, ARENE is playing a leading role as an interface between the demand side, which has been growing rapidly over the last five years, and the supply side, i.e. mainly architects or engineering offices with specific skills in sustainable building, and, to some extent, building materials suppliers or contractors.

To take things further, those services and surveys are followed by various strategy forums run with all of the players in the construction project. The main themes are the contribution made in the future by the HQE building process to the sustainable development of the region (the local Agenda 21 broken down sector-by-sector), and the relationship between eco-building and sustainable planning and urban development.

Sustainable Housing Design for the 21st Century

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1. INTRODUCTION

UN projections show that between 2020 and 2025, the worlds population shall more than double in size from 2.4 billion(1995), to 5 billion. The proportion of this population that is expected to be urban is proposed to rise from 47% to over 61%.(P. Hall, U. Pfeiffer, 2000) To corrospond to these demographic milestones, some 3.8 million new homes are proposed to be built over the next twenty years in the UK.

Taken as a whole, the collective impact of these houses in respect to their environmental, economic and socially sustainable resources has potential detrimental effects if housing continues in the same nonchalant direction. The direction we refer to, the associative materials, typologies and methods of procurement, derive from past cultures and lifestyles and to a large extent, have little comparison to the atypical social landscape of the 21st century, and the very different lifestyles we now lead.

2. CITIES

Relating to these two demographic milestones, many current issues regarding how we live in, use and work in cities are being asked and debated throughout the world, but do we need to readdress the larger picture in respect to how we perceive cities? What is a city and what does being attached to a city mean as we have left the novelty of living in a new millennium behind and begin to seriously address the issues surrounding how we live, or will be living in the future.

What makes a city ‘a city’, is the sheer density of people residing in one area, living working shopping and being entertained. The role of the city in this sense was to reduce the logistical costs of living. Over the centuries, cities have transmogrified, shaped by their own individual characters and regional settings to become almost self propelling machines of consumption. In short they have reduced their inhabitants down to consumers. City centers that were once vibrant and full of social activity were replaced by offices and shopping centers, reducing their daily role in the city by half as these spaces, not being occupied at night, became spaces of anxiety, borders which many of the cities inhabitants were afraid to cross at night.
As the inhabitants of the city were dissipated, the cities footprint grew turning valuable green belt land into suburb or endless roofs of social housing.

2.1 Kingston-upon-Hull

Before the second world war, the city centre was a bustling social space, but as housing was either cleared or destroyed, new estates emerged to the north, east and west of the city. The result was that the city rapidly began to spread. This demographic shift saw these areas divided into the common phenomenon of popular expensive suburbs and council estates full of the social problems on any such area in England or Europe. How then should such issues be addressed?

Kingston-upon Hull, like most northern cities in the UK has suffered economically from the industrial decline in the latter half of the twentieth century. High rates of unemployment and a declining river industry have seen many of the cities areas neglected in addition to the outer estates.

2.2 Future Strategies

Hull has a unique advantage in securing a strategy for the future. It is in the position of part owning its own telecommunications network. Part owned by the city's council and part by Kingston Communications, initiatives have been put in place to take steps in developing a regeneration strategy which aims to propel Hull as a cutting edge city and in the top ten in the UK. In the next few years some £40 million will be invested in ADSL connections to some 110,000 homes in the region, creating a community network broadband connection opening up new possibilities.

As the cities emphasis is changing from industry to one of learning and research, the identification of the challenges and unique possibilities which lie ahead have been formed from a partnership between the city council and the Centre for Regional Studies (CCRS) who have laid out key areas in;

- Falling population levels.
- Above average social deprivation.
- Lack of quality housing/ High percentage of rented properties.
- Poorly skilled local labour market.
- Depressed local economy.
- Low education and training aspirations.
- High crime rates.
- Poor health levels/ High mortality rates.
- Increasing traffic pollution and congestion.
- Poor support and leisure facilities.

To combat such issues the city has taken on board a strategy of reincarnation as opposed to the more restrained regenerative policies. This is reflected in what can be called the 'Digital City Programme' (DCP).

The DCP takes advantage of Hulls position in the telecommunications field, pushing the boundaries of technology and its connections to create a viable feature of its future strategies. This has been taken forward as a genuine sustainable regeneration strategy by the 'digital city task group' who is charged with the responsibility of achieving this vision. It has drawn up its own set of objectives to achieve this which include;

- Integrating the opportunities and practices of information technologies into the current and future life of the city.

- Transforming the economy, business and employment to create a prosperous economy in line with the information age.
- Create an intelligent knowledge driven city.
- Include all citizens and communities in the opportunities for a prosperous, healthy, safe and sustainable quality of life.
- Become a beacon for good governance, participation and public service development and delivery.
- Apply information and communication technologies to innovate, pioneer and modernize.
- Fulfill Hulls unique opportunity to benefit from the information age.

To realize these propositions, the objectives of the task group need to be incorporated into 'live' projects. Already many projects, epitomized by the newly opened 'Deep' with its business and research center by Sir Terry Farrell, has become the first stepping stone to an economic regeneration along the 'heartlands,' a once deprived industrial area along the river hull corridor set in the old center of the city. It is envisaged that the development of a digital creative industries cluster/ development zone as a project for the heartlands would not only feed and supply the city wide interactive television initiative, but also has the potential to create dynamic live/ work environments that could physically anchor a social livelihood back to the city's center.
Within these innovative clusters is the question of how should these new homes reflect such an experimental technological lifestyle? How could the old typologies, if at all, fit into these new clusters? Or would the creation of a totally new house typology be required for the atypical social landscape with its more diverse lifestyles?

3 TYPOLOGIES

The design of housing has become central to the debate on the future development of cities. The pressure to provide more affordable housing relatively quickly has seen many new developments in materials and methods, the emergence of modular construction forms and new ideas about the spaces in which we live in our towns and cities.

3.1 Flexible Building Systems

The issue became more apparent in the closing decade of the last century about flexible buildings, especially in housing, in relation to a viable environmental consideration, especially with regard to the concept of lifetime housing. It is established that more traditional house-building methods incur large costs and timely interruptions during construction, renovation or additional work as many try to adapt their houses to meet their own or changing lifestyles. A home suitable for one family's lifestyle can be totally unacceptable for another. In addition, the separation, or increase in a families circumstances create a new set of considerations and spacial requirements. It has become an accepted fact that we no longer live by a static set of conditions on which past typologies were built. Families change and the need to change our own environments on an increasingly regular basis has seen the emergence of innovative construction methods and levels of detailing.

One such project which has incorporated such issues is the modular housing scheme in Murray Grove, Hackney, London, by the architects Cartwright Pickard (yorkon 2001). The scheme aims to deliver affordable housing to key workers in the city, many of whom cannot afford to live relatively close to their places of work, and like so many city workers are being pushed further from the center of our cities. The modular living units comprise of two or three sections which have the ability to easily change their internal layout from a suitable

environment for a young couple with a small child, to an arrangement which would suit up to three young people sharing in a bed sit arrangement. This is done at little cost and disruption to the occupier making it increasingly possible for a living environment to adapt more quickly to social need and circumstance.

In addition to the more obvious economic benefits, planning for future change in this way would mean that a person could live in the same house through many different and often unexpected changes that they might incur in their life. This issue of 'lifetime' housing, closely related to accessibility in buildings, has been brought to the forefront of the housing issue by the introduction of part M (approved document Part M, Building Regulations, 2002) of the regulations in the UK, and grown to form a major area in rethinking housing. By contrast, old typologies, consisting of bricks and blocks arranged in semi, detached or terrace formations resemble a static and somewhat inflexible culture of lifestyles past, when there appeared some 'unwritten protocol' of how family life was arranged and carried out. Such types based on special requirements attached to set living patterns and functions such as kitchen, living room, bedroom, drawing room, sitting room etc resemble little of the daily programme in this century.

3.1.1 Accessibility and Flexibility. During the 1990's the governments decision to extend Part M (especially in relation to Part L regarding the conservation of fuel and power) (approved document Part L, Building Regulations, 2002) of the building regulations to cover housing came from such issues regarding how we live, and the considerations for a wider section of the public including elderly and handicapped people. Part M deals with accessibility and was formerly used predominantly in the design of public buildings. These regulations came into force in 1999 and in addition to covering accessibility, they attached to this concept of 'lifetime housing,' aiming to 'build-in' flexibility which may make it easier for a person to adapt their home as their social circumstance changed. The idea of adaptable housing is widely acclaimed on the continent and can be found in many European countries including Finland, Greece, Italy, Spain, Sweden, Switzerland and the Netherlands. The criteria for lifetime housing is different from country to country, although extensive research by the Joseph Rowntree Foundation in the UK.(Joseph Rowntree Foundation, 2001) has established the following basic guidelines which include;

External

- Parking space capable of enlargement to 3.6m
- Minimum distance from parking space to entrance
- Approach paths suitably wide and level or gently sloping
- Wheelchair accessible lift
- Covered and illuminated entrances without steps

Lower floor

- Wide front door and ample hallway widths
- Turning space for wheelchair in all ground-floor rooms (1500mm)
- Wheelchair accessible downstairs toilet/ shower provision
- Sitting room at entrance level
- Walls in bathrooms and toilets capable of taking handrails
- Bed space on ground floor in two storey houses

Upper floors

- Bath/ bedroom ceiling capable of supporting lifting hoist
- Provision of future stair lift and space for through floor lift
- Easy access bathroom layout

Features and Fittings
- Window sills no higher than 750mm, windows easy to open
- Switches, heater control etc, easy to reach

3.2 Smart Typologies.
The resurgence of modular construction can also be closely linked with current employment trends. The different materials and trades used in the construction appear to more closely resemble those of production and off-site working methods. The gradual decline in trades in the UK over the years in favour of IT, tourism and banking as reported in the recent Construction Industry Training Board report, 'Skills Foresight' has meant that the industry needs to recruit some 380,000 new trades-people in the next five years to prevent a manpower crisis. (CITB, 2002) This shortage of site based trades will inevitably be reflected in more expensive wages, and as it filters through the system the cost will obviously come out of the pockets of the would-be buyers. In the Yorkshire and Humberside region alone, it is estimated that the skill shortage reflects some 3,500 managers and 5,500 carpenters and joiners.

The question perhaps need to be asked then, with high unemployment such as that which is witnessed in Hull, why is there such a shortage of tradesmen and women? The construction industry already employs one in fourteen of Britain's working population, and to attract more would inevitably include the rise of salaries and benefits, which again would be reflected in housing prices at the expense of the would-be buyers. Such important issues are being raised as the council looks at new initiatives to improve and enhance its own housing stock.

The resurgence of modular housing, also includes the resurgence of methods of production as opposed to construction which may in some way invade or support it, as was seen during the post-war housing crisis? Kingston-upon-Hull's declining industry culture, in this way would be seen to receiving a boost from the newer pioneering industries of its communications counterpart. Hull has major business links with such industries as shipbuilding, caravans and other mobile buildings which could provide opportunities if fully utilized towards new housing types. The effect of this could be seen geographically, as new typologies grow from declining regional industries, creating modern hybrids resulting in economic injections into such important economic areas. The consequences of such economic strategies would hopefully create a more regionally inspired, affordable housing, stamped with the identity of Hull resulting in the rise in the economic boost that Hull, like many others in the north of England requires so badly. The creation of these 'new' typologies, together with the new technologies, could see the city center as a bright social area once more, with the inclusion of a densely populated heartland.

4. SMART COMPONENTS AND MATERIALS
Monsantos house for the future, developed in the 1950's embraced the new plastic materials, and was thought to be the future of housing with such innovations including insulated glass walls, picture telephones, plastic chairs, microwave ovens, speaker phones and electric toothbrushes. (website, 2002) The reasons such schemes, along with the many failed post-war modular housing attempts, were not realized, is that houses are not just the expression of technology and culture, they are an expression of the people who reside within them. The

change in lifestyle in the latter half of the last century, has far surpassed that in the previous half. The psychological attachment that we now have, in regard towards the house and its associated materials is far more open than any reserved attitudes in the fifties. The need for environmental products has seen the use of recycled materials, in effect waste, being used extensively. New environmental appraoches have broken boundaries that many had in accepting the new or different when delivered under this green banner.

4.1 Material Psychology

This has made possible the use of such materials as cardboard, paper products, and more extensive use of its parent, timber. All of which have a low environmental energy and are recycleable. The resurgence of the low-tech solutions makes for an interesting solution to the high-tech lifestyle that is being investigated in Kingston upon Hull. The way we live is increasingly being surrounded and held in place by technology and this does not appear to relate to the physical structure of our habitats. As fast as technology is pushing its boundaries in one diection, sustainability is diversifying the use of materials and the boundaries of their aplications in the other. Increasing use is being made from other low embodied energy materials in addition to waste card, such as straw bales and earth rammed wall structures, materials that would normally be attached to pioneering buildings, but are fast becomming realised as main stream possibilities.

5. CONCLUSION

Hull's unique technological position as we embark on this next century is the ideal platform for the reincarnation of a city creating a new digital urban fabric. The new housing that is required, if informed by this and the regions existing industry sector could form an economic and sustainable catalyst for more innovative housing typologies including the new live/work digital clusters, and low tech innovative use of materials. The more unreservedly we view materials and associative processes, the more we could open new paths for interesting hybrids of high and low tech solutions to Hull technological reincarnation. The question remains is that if all these opportunities are seized, what will the urban fabric, and Hull as a community look like in ten years time?

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A study on the standardization of the building external cost assessment

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1. INTRODUCTION

Recently, the problem concerning the construction project costs reduction of public construction etc. becomes more and more important in Japan. The construction activity consumes a huge resource and energy along with the production of materials and components at present, problems of carbon-dioxide emissions and the construction waste through all buildings lives are actualized. So the influence on the global environment and living conditions becomes one of important problems. When construction projects are executed, it is necessary to evaluate the negative influence for environment through buildings lives(planning, construction, maintenance, dimolition, and recycling) appropriately as an external diseconomy, and to decrease the cost of the whole society by construction projects. In this research, it is defined with external costs, as costs caused by construction activities and third person loses or added to whole society or administration, and excluded in calculation of construction costs. Figure 1 shows the outline of construction project costs seen at the life cycle of buildings. Concretely, costs related to environmental loads such as global warming and waste treatment, resource energy consumption such as fossil fuels and living thing resources, the future risk including safety of structure, noise under construction, spectacle destruction, and traffic jam because of regulation of traffic are given as cases of external costs. External costs are caught from two aspects of influences on the global environment and on living conditions, and disbenefit in this research. It is necessary to consider the construction project costs that whole society bears as a sum of construction costs and external costs, and to evaluate buildings not only benefit came from all those lives but also disbenefit of whole society.

This research is done as one of technology development project, ” Development of technology for reducing construction project costs, including external costs” of Ministry of Land, Infrastracture and Transport in Japan. In this report, verification cases with technologies developed for decreasing external costs are shown, and the outline of the environmental assessment system developed for the establishment of the more overall evaluation system is presented.

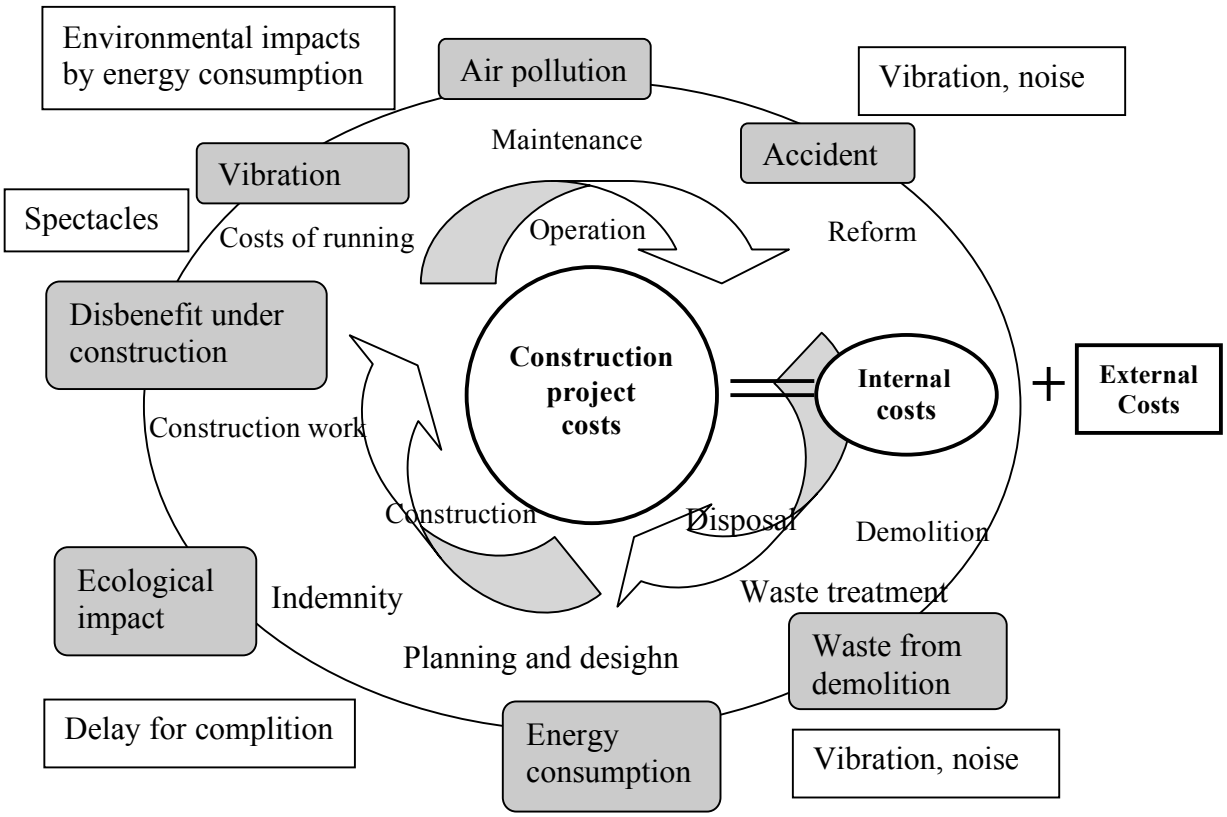

Figure 1 the outline of construction project costs

2. ILLUSTRATION OF EXETERNAL COSTS EVALUATION

This section addresses the following technologies developed in this research as examples of evaluation.

a. low environmental loads-cement bonded unused wood-wool and flake boards

b. universal designed houses

Table 1 shows factors verified as decrease of external costs and the result of that.

In this section, the effect of decrease of external costs from each technology are verified, but the assessment system to evaluate a long series of environmental impact quantitatively is necessary. The details of the system developed in this research will be described next section.

3. BUILDING EXTERNAL COSTS ASSESSMENT SYSTEM

3.2 Outline of the system

The goal of the building external costs assessment system which establishes is as follows.

1. This system has allowed person assess and product buildings to have common recognition over factors of environmental impact, calculating method of quantitative points and setting weight for those factors.

2. The system has high correspondence to social trend, recognition to environmental impact, technical improvement.
3. It is expected that the system presses the environmental consideration type construction production with the environmental consideration and the competition for appropriate construction costs.

Table 1 Illustration of technology and evaluation

Technology	a. Low Environmental Loads-cemented Exelsior board with Unused-wood	b. Universal Designed House
Comparison Object	cemented exelsior board	ununiversal designed house
Verified Factors	amount of carbon exhaust amount of materials use amount of recycling materials use amount of depleted forest resource use and amount of energy use	nursing costs nursing loads QOL
Description Level of External Costs	amount of exhaust (quantified by LCI or LCA data)	Costs (estimated from conparsion factors)
Measurement Data	carbon exhaust of manufacturing, transportation and each raw material etc.	nursing time and physical loads and mental loads, etc.
Outline of Result	amount of generation of carbon dioxide: 7kg/ board in this tech. 10kg/ board in comparison tech. It is assumed that the external costs reduced 2or3 yen/ board (2300yen/ t-C)	It is assumed that the external costs reduced 520,000 yen/ month with non-heavily handicapped person

Figure 2 shows the outline of the system. This system is composed by the environmental assessment system and the external costs evaluation system, and the environmental assessment system are mentioned mainly in this report. Buildings are totally assessed with evaluation points from the view point of environmental consideration by the system.The basic of the evaluation is shown as the environmental assessment matrix. The matrixshows environmental consideration around construction of buildings, by developing life cycle plan stage with action, those qualities and performances for X-axis, various environmental problems for Y-axis. Evironmental problems in Y-axis are extracted by referring environmental assessment tools etc., and classified into three three (a global environment, a regional environment, and the living environment). On the other hand, the evaluation factors on the planning stage in X-axis are classified in five stages. Buildings are totally evaluated with the environmental consideration evaluation point calculated from the matrix evaluation, the specification grade evaluation, and the extra evaluation based on the matrix. Outline of Each evaluation method and the method for evaluation point is described since the next paragraph.

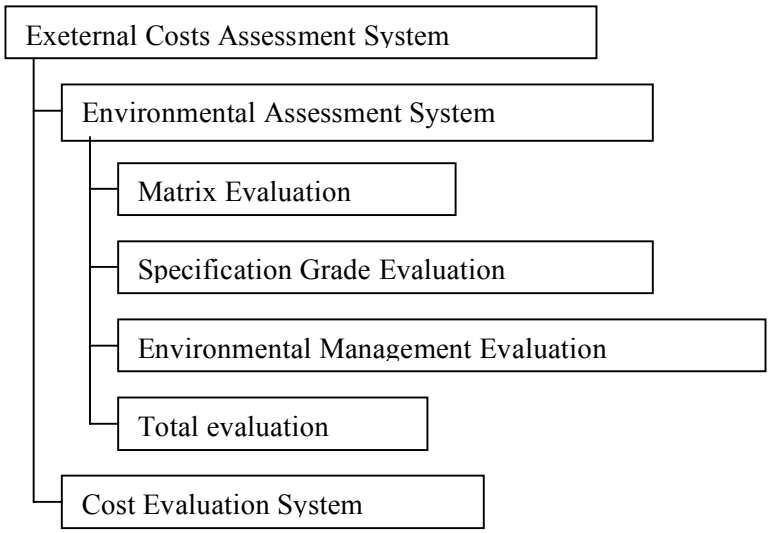

Figure 2 Outline of external costs assessment system

3.2 Outline of the matrix evaluation

Basic environmental consideration is evaluated by the situation of adoption of environmental consideration technology based on the environmental assessment matrix as the matrix evaluation. Concretely, the point is calculated from the weight of factors for each environmental factors adopted environmental consideration technology, and point summed up all points are matrix point, Σ(MP)ij. The weight putting was done by the questionnaire for purchasers, designers and constructers etc. Basic point (MP) ij is calculated by the multiplication by each weight coefficient of evaluation matrix X-axis and Y-axis.

3.3 Outline of the specification grade evaluation

The level and the effect of the executed environmental consideration are evaluated as the specification grade evaluation. Environment Assesment factors, important in the matrix and the criterion are selected, shown in Table 2. Each evaluation factor was extracted from laws, indicators, standards, and standard specifications, etc. As a result, most of them are qualitative evaluation methods, because the data base concerning the evaluation of environmental consideration is not well-prepared, and the calculation method is complex, is not suitable for simple method. Those factors are evaluated by selecting the grade, graded in 2 to 5 levels. In zaddition, the weight is multiplied to the grade, and the total points are made grade points.

3.4 Outline of the environmental management evaluation

Possession of tool achieves environmental consideration is evaluated for desire as

environmental management evaluation. Evaluation objects set from the area concerning the quality system and the quality control. Purposes of the evaluation object a. to c. are recognized as organizational goal of manager, clarification, system of execution, various procedures, and document management checks, and the inspections. Concretely, 10% of the entire evaluation including the matrix evaluation, the specification grade evaluation, and the environmental management evaluation is made an extra distribution point by the environmental management evaluation.

Table 2 Targeted environmental assessment factors

Environmental Assessment Factors	Factors Corresponds to Matrix	
	Environmental Problems	Stage on Life Cycle
Global warming prevention by energy conservation	Global warming	Energy conservation
Resource maintenance for by superior inclination	Resource depletion	durability
Resource maintenance by non-dryness energy	Resource depletion	Operation energy
Prevention of atmosphere, water quality, and soil contamination	Regional environmental ollution	environmental loads
Generation control of waste	Waste measures	environmental loads
Promotion of recycling	Waste measures	Circulative
Urban climate improvement	Urban climatephenomenon	Habitability
Disaster measures	Regional disaster prevention	Safety
Exclusion of poisonous substance	Indoor environment	Safety
Universal design	Welfare living environment	Safety

3.4 the total evaluation

The total evaluation is done by convenient evaluation and detailed evaluation according to scale of buildings, evaluation time etc. Figure 3 shows the flow of the total evaluation.
Environmental consideration evaluation point (TP) is calculated by points, MP, GP, EP, as follwing formula 1, 2.
convenient evaluation: TP=MP +EP (formula 1)
detailed evaluation: TP=MP+GP+EP (formula 2)
When TP is calculated, it is assumed that the weighting factor α, β, and the γ to MP, GP, and EP are multiplied. The weighting factor is set according to the improvement of the acknowledgment level for environmental consideration, component ratio of each distribution points etc. Moreover, which method to use is decided from judgment of the evaluator. It is necessary to execute the case study, and set the target value of TP in the future.

4. CONCLUSION

The target of this project was decrease of the construction project costs expensed by the society with presenting the standardized technique for the technology assessment and inducing the development of the low environmental impacts technology in the private organization from the standpoint of the administration. The approval of the frame calculating values of money as universal index will be done by developing the environmental assessment tool. It is expected that the incentive to technological development in the private company increasing more by evaluating the cost value of the environment had not been specified

enough till now. However, the concept of an external costs is not based only on a monetarism. It is thought that a new society and the economic system like natural capitalism put environmental benefit in are necessary to create the sustainable society.

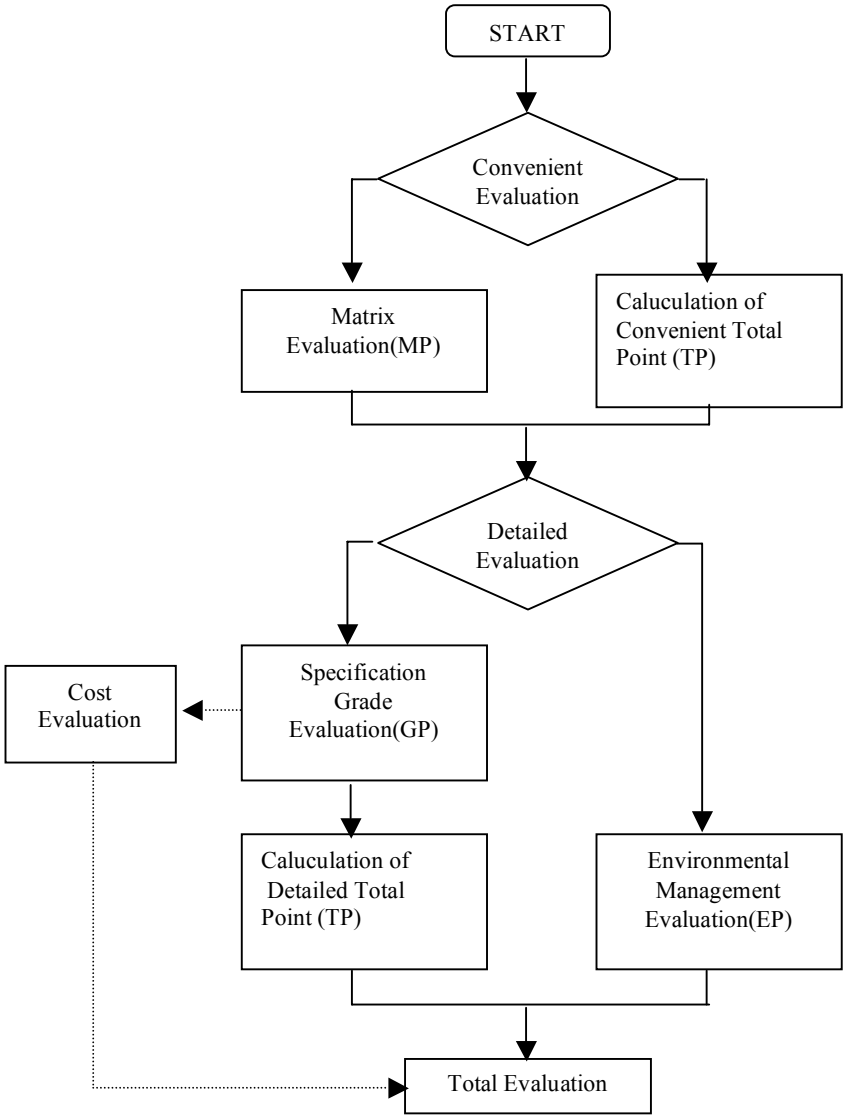

Figure 3 Flow of total evaluation

ACKNOWLEDGEMENTS

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Affordable, desirable and sustainable housing: Test House #1

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INTRODUCTION

Recent housing research in New Zealand suggests that three related factors govern the overall success of a house design: affordability, desirability and sustainability (Gray et al. 2001). At the most basic level, 'affordable' means within the capacity to pay. Affordable housing for the individual occupant (or household) means that the housing is within their capacity to pay initial costs, (or an appropriate ongoing rental) and operating costs.

A similar concept applies to groups, nations, and the planet. Affordability for the planet means that the cost to the planet of consumption and production of waste, particularly toxic waste products, is within the capacity of the planet to provide the resources from the earth's crust, and convert the waste back to the earth's crust in a natural (original) state, at a rate corresponding to consumption. Thus, at a global level "sustainable" means the sum of human practices that leave a planet capable of providing for future generations, while meeting the needs of the present generation. At a local level, sustainable means the sum of practices that make it possible for individuals, households and groups to *keep going* and to *prosper* or be *nourished* in body and mind, without depleting the capacity for others to do the same.

Affordability and sustainability are not sufficient, however. A house also has to be desirable. Obviously this word has its difficulties because it can be taken to mean 'luxurious' or something similar, beyond the reasonable needs of people. 'Functional', or 'serviceable' are related terms that might be used but they imply *neutrality* or *minimum,* neither of which has a sufficiently positive aspect. A 'desirable' house *promotes* things such as well-being (as distinct from being neutrally 'healthy); it provides pleasure, (not simply avoids pain); it is *designed* for occupant control and adaptation, (not designed to prevent change); and it offers the opportunity for self-expression.

A tool for measuring the performance of a house in terms of these three parameters in being developed and tested in New Zealand by the author and others (Gray et al. 2001). From early tests of this tool indicates that it is rare for a house design to score well in all three parameters. Most examples of houses tested so far meet one or two parameter reasonably well, or one very well. The architectural press is full of examples of houses that are very desirable, but expensive and wasteful. One can find examples of houses that are very low cost but not very desirable or sustainable. The challenge for researchers is to develop knowledge and for architects to use that knowledge in the production of houses that work well on all three counts.

This paper describes the results of an attempt by the author, an architect and researcher in the performance of buildings, to design a house that achieves a good balance of affordability, desirability and sustainability. It is called "Test House #1.

THE SITE

At a generic level, the house is designed for a rural site. Typically, this will mean that there is no supply of power or water to the site, and no drainage of stormwater, grey water or soil water from the site. A specific site matching this generic model has been selected for Test House #1. The site is undulating ground near a gorge, with the river some 70 metres below the level of ground on which the house is to be sited. It is not possible to take water from the river, partly due to the difficulty and expense of pumping it up 70 metres, and partly because the pump and pipes would have to be on crown land, involving lengthy and expensive negotiations with a regional authority that manages water catchments. The land is currently a combination of pasture and bush and the ground in rocky. An area of ground with a rock outcrop has been selected

THE CLIENT

There is no specific client. As a test house, the specific needs of a particular household, or of a household type have not been considered. However, a range of uses and users has been considered in the design of the interior, including recreational pursuits such as tramping, river rafting and canoeing; accommodation for farmers and farm hands working in remote regions; institutional or religious retreats; and holiday homes. With suitable modifications, this house may also become a possibility for first homebuyers, or as a new design for rental housing in remote townships where the infrastructure is very poor or non-existent, and there are high levels of unemployment.

THE HOUSE

A model is shown in Figure 1 and plans in Figure 2. The main components of the house are:

- Three recycled insulated shipping containers, stacked one on top of the other. The lowest container is a tank room for treatment of wastewater, together with storage space for tools and equipment etc. The middle container has a kitchen and a bathroom. The entry to the house is into the kitchen. The top container has bedrooms – in this version there are three equal-sized rooms each with a double bunk and a single bunk bed, but other configurations are easily achieved.
- A living "cube". This is one room, constructed with insulated 'sandwich' panels (normally used in cool store construction) for the roof and part of the walls, recycled windows, new plywood (for flooring and stairs) and new softwood construction timbers. A stair leads to an internal balcony that in turn provides access to the bedrooms.
- A water tank. This is a cylindrical concrete tank of a kind that is readily available in rural towns in New Zealand. The top is concrete and is capable of taking foot-traffic. This top is used as a platform to provide access into the house, and as a terrace outside the kitchen. A bridge provides access from the rock outcrop nearby, to the top of the tank.

The services and systems are simple, inexpensive and robust. They comprise:

- A wind generator producing 750 watts, and four storage batteries power two 12v water pumps, 12v fans in the kitchen and bathroom, 12v lights, smoke alarms, and a 12v radio/stereo and TV. Much of the equipment is recycled from motor vehicles. In the simplest version of the house, there is no inverter for alternating current, but there is provision in the wiring for that to be installed in the future. There is provision in the design for the addition of a solar panel system to supplement wind power.
- The water tank previously mentioned has a 20,000-litre capacity, from which potable water is pumped to a header tank on the roof, then by gravity to the bathroom and kitchen. The

main tank is supplied with water from the roof. The gutter has a filter system, and a flushing system to automatically (but mechanically) divert the first 20 litres of potentially soiled water run-off from the roof when it rains.

- A four-tank water treatment plant with filters. Wastewater (both grey and soil) from the kitchen and bathroom is drained into the first in the series of tanks placed in the tank room immediately below. Clear effluent from the last tank is pumped onto the land.
- The kitchen has a sink, and a gas bottle for a two-burner cooking top and a small gas refrigerator, all second-hand.
- The bathroom contains a large sink that doubles as a hand basin and a laundry trough, a WC, and a shower over a 'wet floor'. The bathroom also contains a hot water storage cylinder. All fittings and fixtures are recycled.
- A solid-fuel stove is located in the living room close to the kitchen and the water tank in the bathroom. As well as providing for space heating, this stove has an oven, a cooking top and a 'wet back' to heat the water in the hot water storage cylinder.

Test House #1" has a floor area of 70m^2, plus sheltered space of 15m^2. It has up to three double mattresses and three single mattresses in three bunkrooms, together with space in the living are for couches that can be converted into beds. As a house for permanent occupancy, one of the bunkrooms would more than likely be used for storage. With this arrangement the house could accommodate 3 to 5 people. Fully loaded, but on a short-term basis, the house could sleep 9 or 10 people.



Figure 1 Physical model of Test House #1

1 Footbridge 2 Terrace (over tank) 3 Entry/kitchen 4 Bathroom 5 Living area
6 Bedroom 7 Balcony

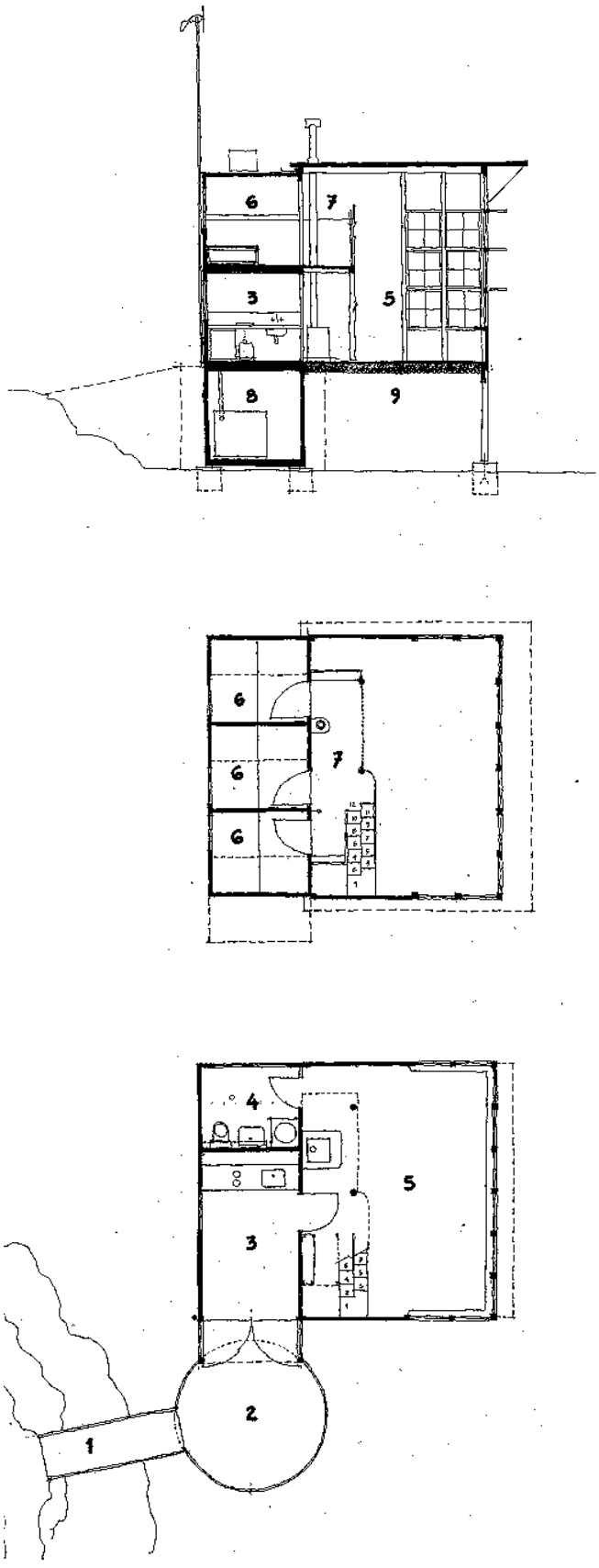

Figure 2 First floor and second floor plans, and typical section of Test House #1

TOWARDS ACHIEVING AFFORDABLE, SUSTAINABLE AND DESIRABLE HOUSING: 14 MEASURES ADOPTED IN TEST HOUSE #1

1 Zero waste during construction. Waste is minimised by modular design, and the selection of materials that allow for modular design. The objective is to use all materials in the form and dimensions as manufactured and supplied. For example, the design dimensions should exactly match standard lengths of timber as available from the lumber yard; panel materials are used in the available sizes without cutting, or cut into parts and used without waste. The key idea is to design for a construction process for *assembly on site*, minimising the need for cutting, forming and shaping building products on site. This strategy also results in shorter construction times, and lower labour costs. Another factor to consider in reducing waste is to reduce the amount of transport needed bring materials to the site, and to set up facilities for the construction crew. Here, the three containers are used to transport the materials needed for the house, and store them on site.

2 Use of recycled materials and waste products and design for recycling in future. Recycling helps reduce the rate of extraction of material from the earth's crust, and pollution resulting from manufacture. It can also be cheaper. In Test House #1, three insulated shipping containers are deployed. Most of the fittings and fixtures used in the house are recycled too, from building recycling depots, and car wrecking yards. In the kitchen: bench and sink, taps, refrigerator, gas bottle, cooking top, 12v extract fan, 12v lights etc. In the bathroom: WC and cistern, sink for hand washing and laundering clothes, hot water cylinder, shower and taps, together with 12v fans and lights. All windows in the building are recycled from one demolished building, so they are all of one kind and condition. (The house design was developed *after* finding the windows). Balustrades and some structure are made of peeled branches and saplings obtained from bush areas on the site. In total, about 40% of Test House #1 is made of recycled or waste products. The assembly of the house is designed for easy *dismantling* in future. Bolts are used instead of welded joints in steel; screws are used rather than nails in timber; minimum use is made of glue; and many materials (having been initially used without trimming or cutting) are available in standard form for future use.

3 Minimum use of scarce resources and volatile compounds, poisons and pollutants. Test House #1 minimises the use of PVC, solvents and sealants in general, and maximises the use of materials that are found in abundance and are renewable, such as plantation timbers grown in the country. Materials are selected to minimise or avoid the use of coatings – for example, cypress macrocarpa is in plentiful supply in New Zealand and is sufficiently durable to need no treatment against decay or attach by insects.

4 Low embodied energy materials and processes. The main *new* building materials are timber, with a lesser amount of steel and concrete. Insulation blankets of wool are used in the living room floor and polystyrene is the insulation and composite structural member in some wall panels and the roof. Glass and aluminium are only used in recycled form.

5 Minimum disturbance of the land including minimum excavation. A small 'footprint' makes it possible to preserve more vegetation and more outside space for activity such as play. One building does not make a big difference on its own, but over many thousands of buildings there are appreciable gains in lower infrastructure costs per household, improved air, lower temperatures in hot weather and less reflected heat off hard surfaces, and other advantages. Reduced disturbance of the ground is also important ecologically. Test House #1 has a small footprint compared with the total floor area, and has only nine footings.

6 Maximum interior volume for the materials used. Many people respond positively to interior space that is generous in volume. Increasing volume means increasing the quantity of

material used in construction, but if appropriate materials and dimensions are adopted the added cost can be insignificant. Test House #1 has a near-cubic volume in the living area.

7 **Design for change:** Houses need to be designed for change, not for 'permanence' (Brand 1994) The floor area and shape of habitable rooms is one of the factors affecting the adaptability of a house. The living area in Test House #1 can be configured in different ways for eating, sitting, entertaining, meeting and (sometimes) sleeping.

8 Maximum efficiency in spaces used for single purpose. When space is intended for one main activity it can be sized fairly precisely using ergonomic principles. In Test House #1, the bedrooms follow this principle.

9 Multiple duty design – one product or system that serves multiple functions. The objective here is to reduce the amount of material used, without compromising overall utility. For example, the stove in Test House #1 serves three functions – heating space, heating water, and cooking. Another example is the use of sandwich panel construction, avoiding framing.

10 **Inexpensive but robust materials, standard construction methods, simple detailing/finishes.** The principle being adopted in Test House #1 is to use standard products and industrial waste products in innovative ways, rather than innovate with new materials.

11 **Wind generator and low-voltage electrical system and fittings, provision for solar power.** A 750 watt generator and batteries provides for power requirements at a basic level.

12 **Solar gain and insulation for warmth.** Windows facing the sun (with appropriate shading devices that can be adjusted), with fewer window in walls that do not get sun; and fully insulated walls, floors and ceilings/roof.

13 Rainwater storage/supply system Rainwater is first fed into the potable water storage tank, but any overflow is fed into a small wetland area filled with water-loving plants.

14 **Minimum waste off site during occupancy.** The objective is to deal with household waste on site. In Test House #1 soil waste and grey water (from bathroom and kitchen) are treated in a series of tanks fitted with filters, and the clear effluent is then distributed on the land by means of a pump and lines of field drains. The field drains are placed where they will assist plants that benefit from the added moisture. Organic waste is composted on site. Recyclable waste products are taken off site to a recycling depot. The small amount of remaining waste is buried on site in specially dug pits located well clear of waterways.

15 **Careful avoidance of clues to 'cheap' construction.** The objective is either neutral acceptance or positive interest. Test House #1 avoids appearing mean, is simply and well detailed, clean in appearance, and uses culturally accepted elements, such as regular windows. The house also includes some artistic elements – for example the staircase, rather than being ordinary and utilitarian, becomes a sculpture, perhaps an object of desire.

CONCLUSION

The cost of Test House #1, including builder, fees and permits, and including the services as described, is NZD 38,000 (about USD 17,000). This is less than 60% of the cost of a standard New Zealand house of similar proportions, connected to infrastructure services. The design assumes a somewhat Spartan lifestyle, but the exercise goes some way to showing how a house can be made affordable, sustainable and desirable.

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The MaSe-system: A Material Selection system for environmental conscious material selection

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1 INTRODUCTION

This article presents a material selection system (MaSe) that is being developed as a part of an ongoing doctoral study at NTNU. The focus in this presentation is to provide an understanding of the evaluation procedure in the MaSe system, important aspects like data availability and format, how the system is used within the building process etc. are therefore not included.

The background for the work is that about 40 per cent of the materials put into the world economy ends up in buildings. Many building materials contain substances that can endanger both human health and the environment. International agendas, reports from the government, and gradually also laws and regulations, recognises that the building industry, being such a large consumer of materials, needs to include environmental considerations in the acquisition, use and disposal of materials.

2 THE PROBLEM

There are many tools that provide environmental material evaluations of building materials. The best-known tools have been studied and compared to a set of criteria found to be important in a Norwegian material selection system. This includes BEES (USA), Athena (Canada), Guide for Material Selection (Sweden), Environmental Resource Guide (USA), Environmental Preference Method (the Netherlands), BEAT2000 (Denmark), ENVEST (EcoPoint) (England) and the TWIN Model (the Netherlands). Some of them provide solutions that can be used with some modifications, but none is found to fully satisfy the identified needs for a Norwegian system. The most common problem is that a very limited number of parameters are included. Areas like IAQ, toxic substances and economy are often excluded. For others more parameters may be included, but the user friendliness is then reduced. The user is also often alienated from the evaluation procedure, and cannot see the reason for a certain result, or affect the result by setting preferences.

In order to make sure that this material selection system is coherent with the building industry and its needs, some of the central actors in the industry were interviewed. The selected interviewees all agreed upon that considerations regarding environmental qualities have to be included as a criterion when selecting materials. But the actors on different levels in the building process have different needs; all they agreed is that they need some kind of aid in order to set the new requirements into action.

3 THE MaSe-SYSTEM

Multiple attribute decision-making methodologies have been studied, to find a systematic procedure for the environmental evaluation in the MaSe-system. The reason for studying

multiple attribute decision-making is that the problems faced in environmental evaluation are very similar to problems solved with multiple criteria decision-making (Andresen (2000), Balcomb et. al. (2000) Chen et. al. (1992), Hwang (1981) and Yoon et. al. (1995)). Simple additive weighting seems like the best methodology to be used in the MaSe-system, but this still leaves some important challenges. One of the major obstacles is to include both qualitative and qualitative information. The scaling table developed in the MCDM-23 project (Balcomb et. al., 2000) is considered as a solution to this problem. The scale chosen in the MaSe-system is shown in Table 1. The column "Criteria" can include qualitative or quantitative information. The table includes an example of criteria for the raw material type. This will represent the normalisation step in the environmental assessment procedures.

Table 1: Score chart used in the MaSe-system.

$Score_{RmT}$	**Judgement**	**Criteria: Raw material type**
1	Best attainable, excellent	Reuse
3	Good to excellent	Recycled
4	Good	Sustainable renewable
5	Fair to good	
6	Fair	Non-renewable available
7	Borderline fair	
8	Marginally acceptable	Non-renewable limited
10	Poor	Unsustainable renewable

3.1 Description of the evaluation procedure

Evaluation procedures are developed for four different areas n the MaSe system; this is "Resources", "Ecology", "Health" and "Economy". It would be outside the scope of this article to describe the evaluation procedure for all four areas. To provide a good understanding of the MaSe-system, the "Resource" area is presented in some detail in the following. An evaluation of the Resource area includes an evaluation of the raw materials, recycling, energy use, materials for maintenance, durability, re-use etc. associated with the lifecycle of the product.

The classification consists of four main steps, illustrated in Figure 1:

1. "Normalisation": Scoring of the parameters according to the score charts
2. "Combined scoring"
3. "Classification in phases": Classification of the different lifecycle phases, production, use and disposal
4. "Final classification": Weighting of the lifecycle phases to reach one single class for resources, $Class_{Resources}$

3.1.1 **Normalisation.** The scorecards enable the inclusion of different types of parameters, not only the scarcity factor used in many existing systems. An example of a scorecard is presented in Table 1. Scorecards are defined for all parameters listed to the left in Figure 1.

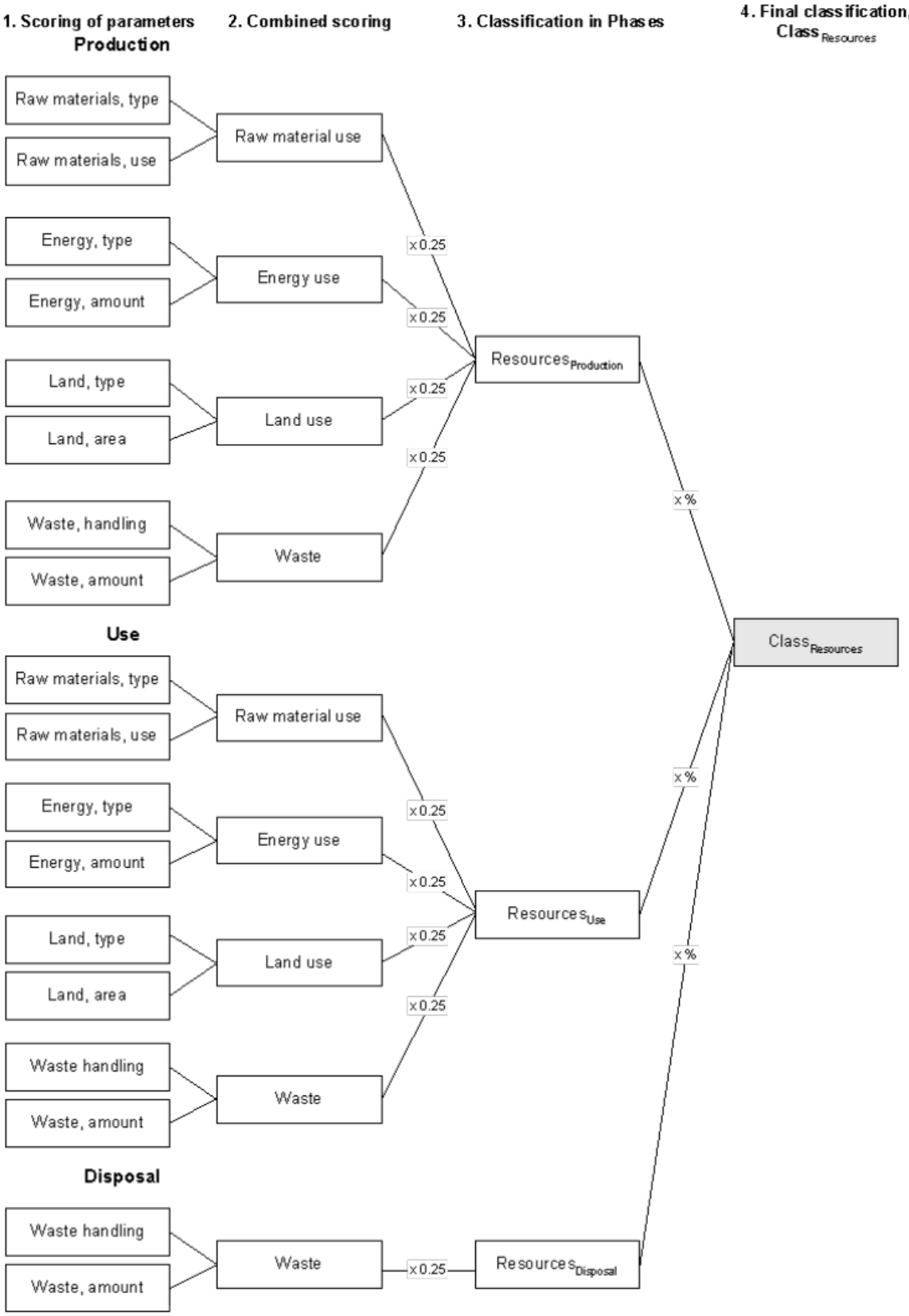

Figure 1: Illustration of the classification of resource use.

3.1.2 Combined scoring. To find the score for the parameter "Raw material use ", $Score_{Rm}$ (see Figure 1), the two scores for "Raw material type", $Score_{RmT}$, and "Raw material use",

$Score_{RmU}$, are multiplied and classified according to a set of classification criteria illustrated in Table 2. The same is done for energy use, use of land, and the production of waste. The classification criteria in the columns to the right in Table 2 is set in order to separate the best and worst materials and to distribute the rest of the materials between them in 6 groups.

Table 2: Example of combined scoring of the "Raw material use".

Use of raw materials; $Score_{Rm}$	**Raw material amount; $Score_{RmU}$**	**0-12.5% of average attribute value**	**12.6-37.5 % of average attribute value**	**37.6-75% of average attribute value**	**76-125 % of average attribute value**	**126-162.5 of average attribute value**	**162.6-187.5% of average attribute value**	**187.6-200% of average attribute value**	**200+% of average attribute value**
Raw material type; $Score_{RmT}$	**Score**	**1**	**3**	**4**	**5**	**6↓**	**7**	**8**	**10**
Reuse	**1**	1	3	4	5	6	7	8	10
Recycled	**3**	3	9	12	15	18	21	24	30
Sustainable renewable	**→4**	4	12	16	20	**24**	28	32	40
Non-renewable available	**6**	6	18	24	30	36	42	48	60
Non-renewable limited	**8**	8	24	32	40	48	56	64	80
Unsustainable renewable	**10**	10	30	40	50	60	70	80	100

Judgement	**Score**	**From**	**To**
Best attainable, excellent	**1**	1	5
Good to excellent	**3**	6	15
Good	**4**	16	30
Fair to good	**5**	31	50
Fair	**6**	51	70
Borderline fair	**7**	71	85
Marginally acceptable	**8**	86	95
Poor	**10**	96	100

3.1.3 **Classification** In the classification step the results from the combined scoring are summed up into a classification of the different lifecycle phases in the respective area. "Raw material", "Energy", "Land" and "Waste" are treated with equal importance in the further evaluation. There are four parameters in the two first lifecycle phases, whereas disposal only has one (see Figure 1). The score for "Resources" in each lifecycle phase are calculated as shown in equation (1).

$$R_{Production} = Score_{Rm}*0.25 + Score_{E}*0.25 + Score_{L}*0.25 + Score_{W}*0.25 \quad (1)$$

Where $R_{Production}$ = Score resources in the production phase
$Score_{Rm}$ = Score Raw material
$Score_{E}$ = Score Energy from
$Score_{L}$ = Score Land from
$Score_{W}$ = Score Waste

The last step involves the final classification of Resources use. The classifications from each lifecycle phase are weighted together. The weighting is performed using the masses of material in each phase as shown in equation (2).

$$Class_{Resources} = \sum_j \frac{score_j * kg_j}{\sum_j kg_j} = \frac{R_{Production} * kg_{Production}}{kg_{Total}} + \frac{R_{Use} * kg_{Use}}{kg_{Total}} + \frac{R_{Disposal} * kg_{Disposal}}{kg_{Total}} \quad (2)$$

Where: j = lifecycle phase
$score_j$ = score for Phase j
kg_j = kg materials in Phase j

3.1.4 **Final classification.** The final classification of resource use is presented in Figure 2 and Figure 3. The classification in classes 1 to 10 is performed after the same principle as the initial scoring of the parameters.

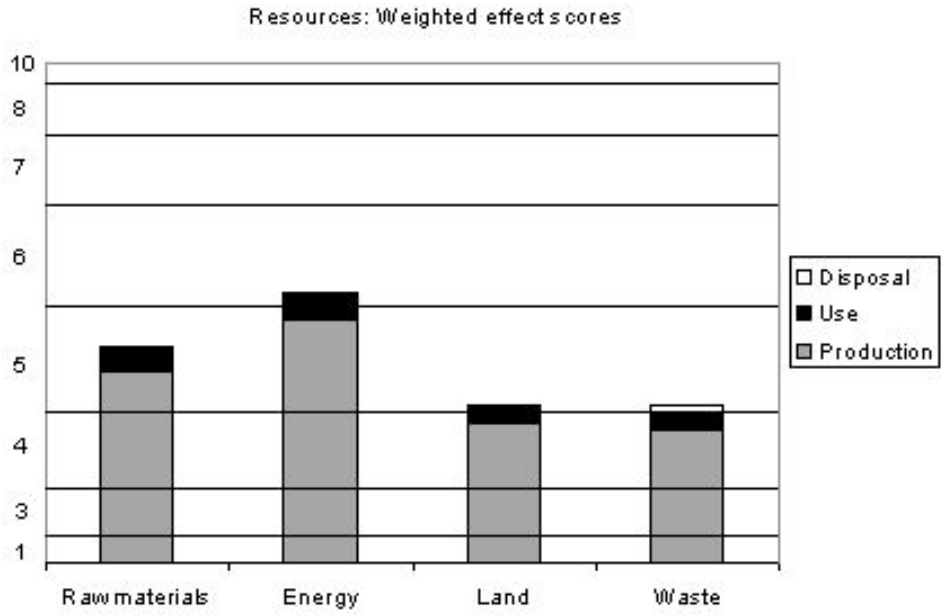

Figure 2: The lifecycle phases are weighted together and the results displayed with respect to the different parameters.

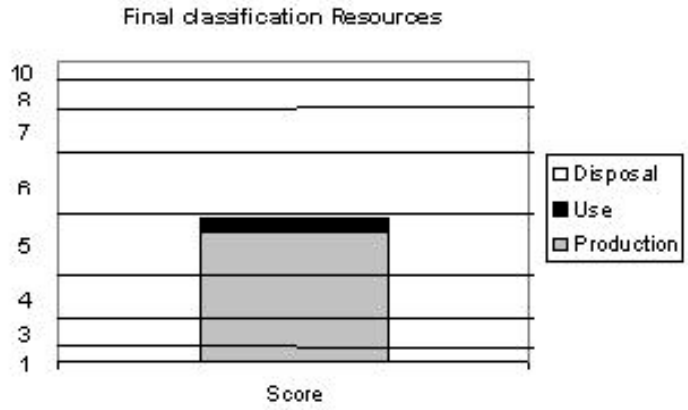

Figure 3: Presentation of final classification results for Resources, $Class_{Resources}$.

3.1.5 **Results for all four areas.** The evaluation procedure of the other areas, "Ecology", "Health" and "Economy", is kept as similar to the "Resource" area as possible. The results can be presented in various ways, one example is shown in Figure 4. If the user provides weights to the different main areas, one index may also be the final result. The user can in

addition, for every material, choose to go into the details considered important to the particular project.

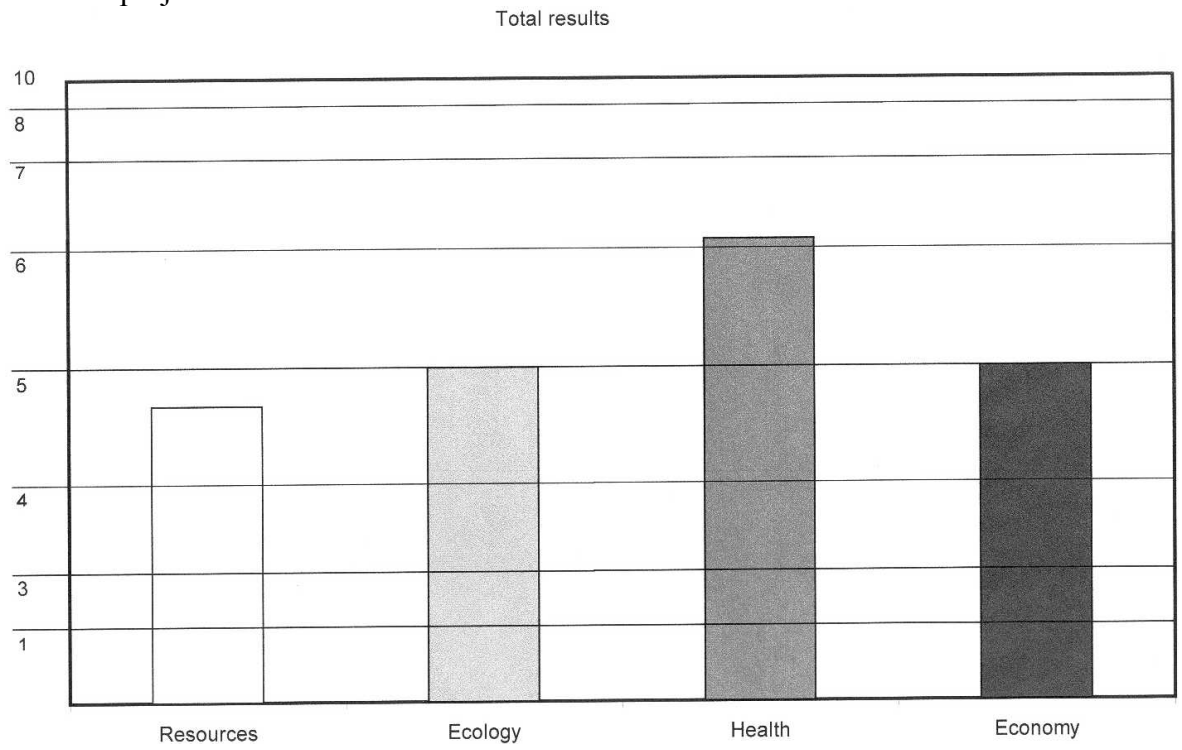

Figure 4: Example of presentation of total result of the evaluation of a building material.

4 CONCLUSION

This article briefly presents the MaSe system, and the work that lies behind it. The focus when developing the system has been on selecting the right parameters and making a system structure that is easy to understand and flexible. Flexible means that it can include future changes in priorities and included new materials as they are introduced in the market, and that it can serve different user needs. The last aspect is important so that users with different roles in the building process can find the system functional. The next step in the development of the MaSe system will be to test how the system at its present stage may satisfy the identified needs of the Norwegian building industry.

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Designing Sustainably as a Team: The Illinois Science Center at Argonne National Laboratory

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INTRODUCTION

Argonne National Laboratory (ANL), located just outside of Chicago, is one of the leading international research facilities in the United States. It is a U.S. Department of Energy laboratory operated by the University of Chicago. The research conducted at ANL falls into four broad categories:

- **Basic Science** – Experimental and theoretical work in materials science, physics, chemistry, biology, high-energy physics, mathematics and computer science, including high-performance computing.
- **Scientific Facilities** – ANL designs, builds and operates sophisticated research facilities that are too expensive for a single company or university to build and operate.
- **Energy Resources** – Programs to help ensure a reliable supply of efficient and clean energy for the future.
- **Environmental Management** – This includes work on managing and solving the nation's environmental problems and promoting environmental stewardship.

THE PROJECT

As a part of this continual quest to achieve greater advances in science and technology, planning has begun for a large addition to the ANL campus. This will allow ANL to pursue its mission of basic research and technology development to meet national goals in scientific leadership, energy technology, environmental quality and national security. The first phase of this campus addition is called the Illinois Science Center (ISC). This building will become a signature presence on the campus and features the highest quality laboratory and research amenities, as well as an auditorium, classrooms, and offices, to help draw international scientists to conduct their research at ANL.

At the very onset of the project, the scientists and facilities staff at ANL requested that the new building be not only energy efficient and environmentally responsible but also have features that allow for scientific innovation and a high degree of collaboration among the researchers. These are the principles on which the architectural and engineering design is based. OWP/P, a Chicago-based, full-service architectural and engineering firm, was selected to design the ISC. To guide the design team, the following project vision statement was developed by the team's lead designer, Bjorn Hallsson:

> Our origin has its roots in the beginning of the universe where the laws of nature form the structure of all things. The forces in nature are perceived as attractive or repulsive, and our existence depends on the balance between these. The continuing search for knowledge and understanding of the forces of nature, and of their consequences, is an

inward-looking process--looking ever closer inside the orbital motion of electrons in the atom, into the atomic nucleus and the orbital motion of protons and neutrons. An important part of the search for deeper insight is based on studies related to the balance of forces within the atom—changing the stability within atoms by splitting protons away from neutrons. Achieving additional knowledge of this is the purpose of this facility and the mission of its research and experiments. It is the universal focus of this research—the atomic nucleus and the manipulation of its parts—that generated the metaphor for the architectural concept of the buildings accommodating the experiments.

CONCEPT DEVELOPMENT

Using as a model the collaborative, cross-disciplinary working relationships of the scientists at ANL, from the earliest concept stage the design team included architects and engineers, as well as ANL facilities and maintenance staff and the scientists themselves. This team stayed together through the final design of the building. The design process started with freehand sketches of the facility, which helped ANL begin to understand how the massing and form of the building could become an explicit representation of the research that will occur there (Figure 1).

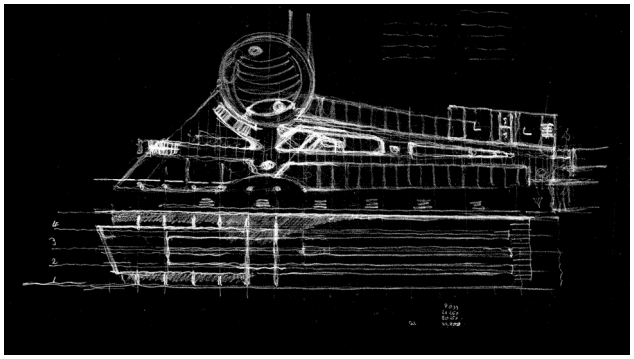


Figure 1 – Early Concept Sketch and Design Model

In keeping with ANL's goals and concerns, early sketches highlighted concepts that promote collaboration, sustainability and energy efficiency, such as external shading, a building shape that maximizes access to natural daylight, an open floor plan that promotes natural ventilation throughout the building, and an atrium that allows for close coordination and collaboration among the scientists. Using the initial freehand sketches for discussion, the architects, structural engineers, systems engineers and lighting designers began a dialog of how best to integrate the structural, mechanical and lighting systems with the layout and form of the building. From these discussions, several design concepts emerged:

- Cost-efficient but effective external shading
- High-performance glazing
- Daylighting to reduce internal cooling loads and electrical light levels
- Underfloor air distribution
- Hybrid ventilation

TESTING THE CONCEPTS

Each of these design concepts, as well as several others, was analyzed and challenged by the entire design team during the early design session. The goal of this session was to prioritize the design concepts that contributed most to the achievement of the project vision. During this session, the design team provided real-time first cost and life-cycle cost estimates of the design

concepts. A parametric energy analysis (Table 1) helped ANL's scientists and facilities personnel compare and weigh the impacts and costs of the different strategies.

System	Description	Annual Energy Costs	Annual Energy Costs per Sq. Ft.	Annual Energy Savings	Percentage Savings	Nominal Chiller Size, Tons	Peak Steam USE, MBH
Base	Base Case	$96,300	$1.36	-	-	209	238
1	Improved envelope with wall R= 19, roof R=30	$95,000	$1.34	$1,300	1%	204	232
2	Improved windows with u=. 3, SHGC=0.24	$91,700	$1.29	$4,600	5%	194	237
3	Shading on southern glazing	$93,600	$1.32	$2,700	3%	196	239
4	Shading on south, west, and east	$88,400	$1.25	$7,900	8%	156	239
5	More efficient lighting system (0.8 W/sq. ft.)	$81,900	$1.15	$14,400	15%	192	239
6	Daylighting	$78,400	$1.10	$17,900	19%	174	241
7	VFD's on fans, pumps, and cooling tower fans	$82,900	$1.17	$13,400	14%	199	239
8	Steam absorption chiller	$92,900	$1.31	$3,400	4%	204	1870
9	Hybrid Ventilation	$70,900	$1.00	$25,400	26%	209	241
	Building as designed	$48,400	$0.68	$47,900	50%	160	694

Table 1 – Summary of Parametric Energy Analysis

This analysis revealed that using all of these strategies together would reduce the building's energy usage by approximately 50 percent. After this session was complete, the final concept of the project was developed, and the design moved forward into final working drawings. At this early stage of the project, the entire team had already developed a high level of confidence that the design was consistent with the project vision and would meet the stated goals of saving energy, reducing the environmental impact, and promoting scientific innovation.

DESIGN STRATEGIES

Based on the experience of the ISC project, it is critical that the systems engineering and architectural design be developed hand-in-hand and that the building owner/occupants buy into the design intent. There are many different strategies for developing an environmentally responsible design—all of which are parts of an overall strategy to create a stimulating and healthy indoor environment and to minimize a building's energy usage. The following strategies were incorporated into the design of the ISC building:

- *Hybrid Ventilation* - Buildings that incorporate hybrid ventilation systems use both mechanical ventilation/cooling and natural (passive) ventilation strategies. The term mixed-mode ventilation is often used to describe these systems. The hybrid ventilation strategy for the ISC requires that the mechanical and passive systems work in conjunction with each other. Since hybrid ventilation systems employ a combination of wind-driven and pressure differential–driven natural ventilation

techniques, the building design (building orientation, depth of occupied zones, operable window locations and sizes, etc.) was critical to the success of the passive air movement strategy. The building orientation takes into consideration the speed and direction of the local prevailing winds to maximize the effect of wind-driven natural ventilation (see the following section for more details on hybrid ventilation).

- *Mechanical Cooling and Ventilation* – In the hybrid ventilation system designed for the ISC, the natural ventilation system is used when the outdoor air conditions are appropriate; mechanical cooling and ventilating systems are used when they are not. In other words, the mechanical systems will be used when thermal balance (no heating or cooling required) cannot be achieved using natural ventilation.

- *Operable Windows* – The ISC will have sensors that shut down ventilation systems (or zones) when windows are opened. This will prevent the systems from working against each other.

- *Atrium* – Buildings with a central atrium are good candidates for applying hybrid ventilation strategies. The natural stack effect that drives airflow up into an atrium will help drive the introduction of outside air through operable windows or fixed building openings at the ISC.

- *Heat Stacks* – At the ISC, heat stacks help drive the airflow through the building by maximizing the natural stack effect.

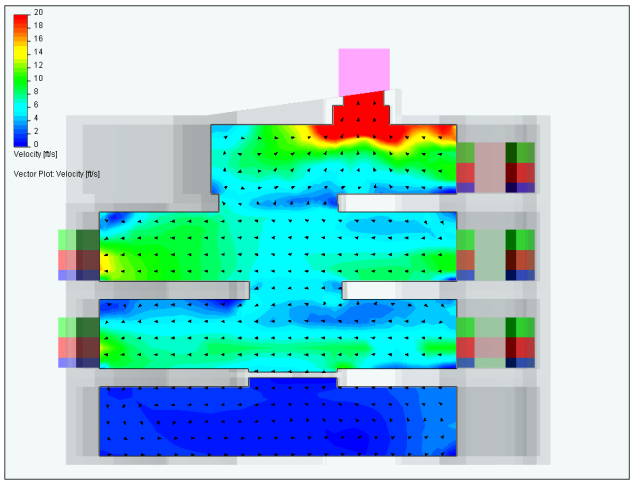
- *Exposed Thermal Mass* – The exposed thermal mass and the use of high-heat-capacity building materials (such as concrete and masonry) are an integral part of the natural ventilation strategy for the ISC. These materials will hold heat during the day and release it into the building spaces at night, when the colder outdoor air temperatures facilitate structural cooling of the building.

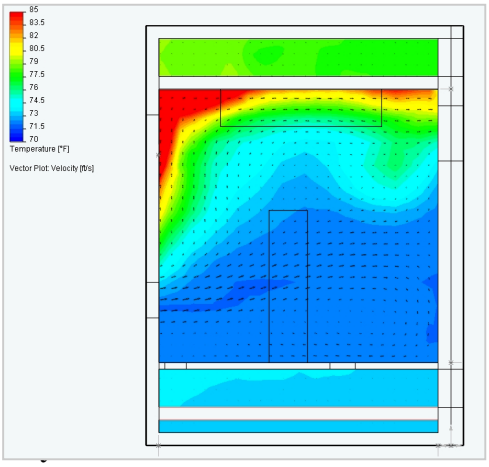
- *Daylight* – Electric light sources are one of the largest contributors to the cooling load of a building. At the ISC, the use of natural light in the daylighting strategies not only decreases the need for artificial lighting but also reduces the cooling load to reduce total electrical consumption.

- *Solar Shading* – In the ISC design, exterior solar shading devices not only reduce the solar heat gain but also act as a light shelf complementing the daylighting strategy. Shading devices on the southerly exposures allow the low-angle sun to penetrate the space during the winter months, contributing to the passive strategies used in the building. In addition, the interior shading devices reduce the cooling load in other areas.

- *Control Strategies* – A robust building management system will be needed to control the operable windows, louvers, dampers, etc., and integrate the operation of the mechanical system with the natural ventilation system. In addition, lighting controls that vary the amount of artificial light based on the available natural light will be employed. The ISC will have a building control system that monitors and controls CO_2 levels and relative humidity to allow for the activation of the mechanical cooling and ventilating system during times when the passive system cannot keep the levels within target ranges.

- *Air Distribution* – Given the variety





hin the ISC, the air distribution concepts were studied in detail to understand how the air will flow through the building in different scenarios. The ISC uses an underfloor air distribution system. Computational fluid dynamics (CFD) techniques were used to analyze air distribution (Figure 2).

Figure 2 – Whole Building and Room Level Modeling Using CFD Analysis

HYBRID VENTILATION

The hybrid ventilation system for the ISC is arguably the most distinctive element of the building's design relative to a "standard" building design. What were some of the reasons that a hybrid ventilation system was chosen for the ISC?

First, during the preliminary design phase, the design team surveyed a small group of international scientists about the environmental conditions that are important to them in doing their research. The survey revealed that nearly all of the scientists requested access to natural light, and many mentioned good temperature control, including access to natural ventilation.[1] The scientists' comments indicated that natural light and ventilation would contribute to the stimulating, collegial, and collaborative environment they envisioned. The hybrid ventilation system plays a major part in helping to achieve this vision.

Second, since the ISC is a U.S. Department of Energy facility, the building must meet stringent energy-efficiency and environmental standards. Studies of buildings using natural and hybrid ventilation systems conducted by CIBSE show a 25-50% reduction in energy use over buildings using conventional cooling and ventilation systems.[2]

Finally, current research indicates that building occupants that have access to natural ventilation have higher satisfaction with their indoor environment, as reported in ASHRAE research project RP-884.[3] Some of the major findings of this research are:

- People adapt their behavior to become more active participants in the control of their environment (such as when they are allowed to open and close windows).
- People will wear clothing with a wider range of clo values that correspond more closely to the outdoor temperature.
- People's metabolic rates will remain fairly consistent regardless of indoor temperature.
- People can tolerate, and perhaps prefer, higher localized velocities, such as natural breezes from an open window.
- People prefer a range of indoor temperatures that have a direct correlation to outdoor temperatures.

CONCLUSIONS

As in any architectural and engineering project, the needs of the end users and operators of the building, the design philosophy, and the budgetary constraints of the project have all played a part in shaping the final solution for the ISC. Projects that feature sustainable design techniques that are integral to the vision of the building require that the architecture and building systems be developed hand in hand. The ISC is a good example of how a nucleus of architects, engineers, building operators and end users can successfully collaborate to develop a well-integrated, stimulating design that can help advance science and technology.

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Sustainability through Optimised Structures Using Recycled Waste

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1. INTRODUCTION

An accelerating development of technology and production during the last two hundred years has been accompanied by a devastating process of exhausting non-renewable raw material sources, and an escalating pollution and amount of wastes. The material and energy resources are limited with respect to the increasing population and human needs. The regeneration ability of renewable resources is limited, non-renewable sources are irreplaceably exhaustible. The construction industry and its products (buildings) represent the crucial consumer of natural resources, a heavy polluter and waste producer. Buildings in the EU are responsible for more than 40% of the total energy consumption and the construction sector generates approx. 40% of all man-made wastes (CIB, 1999).

Among basic actions towards sustainability specified in general Rio Agenda 21 are:
- minimisation of non-renewable resources use,
- minimisation of total waste production,
- maximisation of environmentally sound waste reuse and recycling.

The sustainable development of structural systems and construction technologies should be thus based on the effort to decrease consumption of natural resources while increasing the structure's serviceability, durability and reliability throughout its entire expected life. This requires a search for new design principles that enable reusing of waste in construction in the form of recycled materials. Simultaneously, a complex life-cycle assessment and optimisation of material, energy, pollution, waste, and other flows throughout the whole life cycle of the structure should become an essential part of the quality design approach.

2. RECYCLING – AN ESSENTIAL PHASE OF THE LIFE CYCLE

The total environmental impact of a building should be considered throughout its whole life, from raw material acquisition through production, use and disposal (CEN, EN ISO 14040, 1997). It is essential that the goal of optimisation efforts should be to keep structural materials in a closed material cycle (the grey area in the Figure 1) as long as possible. Consequently, the required reduction of material and energy inputs (especially non-renewable sources) and negative outputs (emissions, wastes and other negative environmental impacts) can be achieved. The vital importance of maintenance, repair and renovation processes, which can increase the durability of building elements and the whole structure, is thus evident. The

recycling phases including inputs and outputs from and to other processes / industries, respectively, can represent a considerable contribution to the reduction of the total negative environmental impact of building construction.

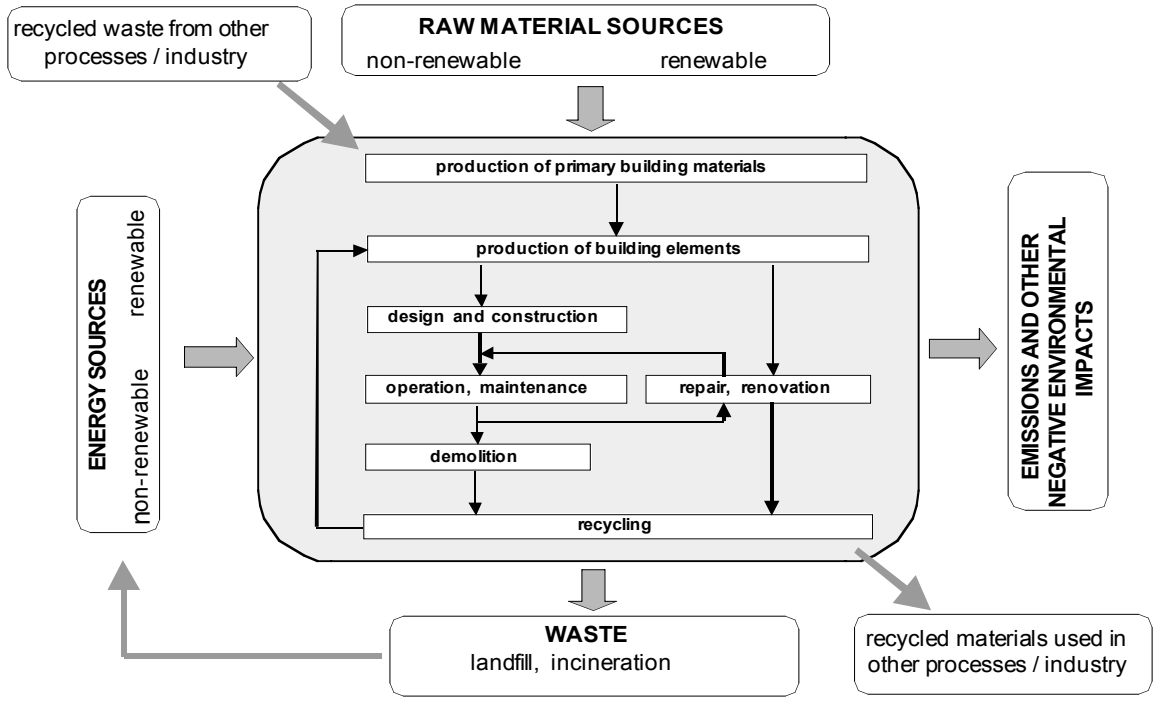

Figure 1 Life cycle of the building – material and energy flows and consequent environmental impacts

The optimisation of material consumption, and/or replacement of traditional materials by others, cheaper or more readily available is not often adopted in the building industry because of the dominating use of large amounts of relatively cheap primary material sources. The reason is that the cost of the saved raw material cannot often cover the higher cost of the more demanding technology. However, the significance of use of recycled materials replacing natural non-renewable sources is evident.

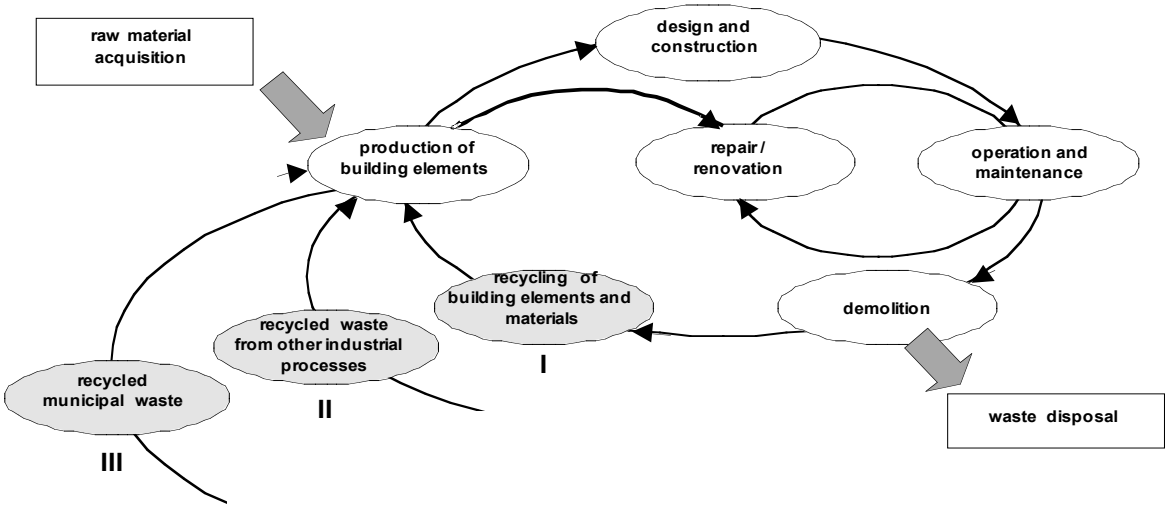

Figure 2 Use of recycled materials in the building cycle. Three sorts of recycled wastes can be used as a secondary raw material for production of building elements.

Building construction typically uses large amounts of materials in relatively less demanding techniques. Therefore, there is high potential for the use of secondary materials obtained from recycling of waste generated by other industrial processes and from municipal waste – Figure 2. This approach enables primary materials to be kept in the material cycle (considering usually longer service life of the building compared to the service life of primary product) longer, thus reducing consumption of natural material sources and production of wastes.

The technical value of recycled material is often lower than that of the material when first used in the primary product (down-cycling). Preference should be given to the high-value reuse of recycled materials replacing high-quality primary non-renewable raw materials. In some specific cases, new products from recycled waste can have a higher performance value in comparison with the primary product (up-cycling).

Recycleability of the new construction from recycled material represents an important aspect that has to be considered. A feasible, effective and environmentally-sound recycling technique should be available for the specific case to avoid the necessity and uncertainty of development of a special recycling procedure. Preferably, the technology process should not limit the number of recycling cycles. An example in Figure 3 shows the potential of use of recycled plastic from throwaway bottles for production of plastic shell elements to be used as a permanent formwork in construction of ribbed or waffle RC floor slabs. The utility period of primary raw material could be thus prolonged several thousands times in comparison to waste disposal (incineration) of used plastic bottles in non-sorted municipal waste.

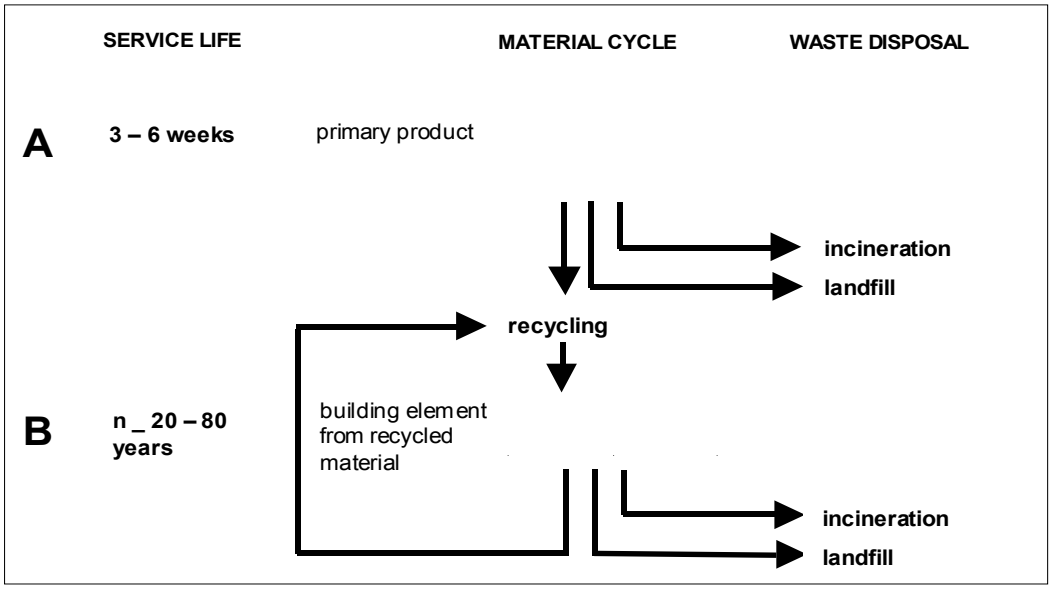

Figure 3 Life cycle of plastic throwaway bottles. A – without material recycling – lifetime 3 – 6 weeks, B – recycled plastic is used for production of building elements – lifetime n x 20 – 80 years

3. HYGIENIC ASPECTS OF RECYCLED WASTE USAGE

The utilisation of the scrap-based secondary raw materials for the production of building elements represents a severe technological problem from the hygienical point of view. Namely, the initial material being used for recycling is contaminated with a variety of organic materials considerably in some cases. In addition, the building materials which are produced

by recycling may cause the escapes of volatile components which are inadvisable and improper for the people that are to stay in a microclimate in question for a longer time. The following from the noxious materials which are escaping from the plastics as a matter of course are specified most often: styrene, cyclohexanone, 2-ethylhexanol, 4-phenylcyclohexane, formaldehyde, chlorinated hydrocarbons and solvents.

If the plastics from the mixed communal garbage are contaminated, in addition, still with food refuse, earth and/or with other organic compounds, then the microbic population growing on the moist and contaminated plastics may produce volatiles of the microbic metabolism (alcohols, ketones, aldehydes, aromatic substances, terpenes) the negative properties of which can be the same as those of chemical substances liberated from some building materials. However, it must be stated that there is no direct proportion between the number, quantity and resulting ecotoxicity in the mixed samples of volatiles and other substances that cause the health problems. The results of analyses made in this respect have revealed that, sometimes, an inverse phenomenon can be observed when a mixture of volatiles has lower ecotoxic effect than its individual components.

The hitherto results of evaluations of the ecotoxicity of recycled building materials obtained by means of specially developed bioindicators have also brought evidence of a considerable dependence between the building element age and the quantity and/or rate of toxicity of single volatiles. It is obvious that in case of recycled building materials it will be necessary to define the time interval elapsed since the production, in which the people may stay in the interior space for a long time. Therefore, the detailed and reliable evaluation of the ecotoxicity of new materials made of the recycled plastics is a problem of principal importance.

4. FLOORS WITH FILLERS FROM RECYCLED WASTE MATERIALS

The basic aim of the research project performed at the CTU in Prague was the environmentally based optimisation of RC floor slabs, including verification of suitability of using recycled materials. Recycled industrial and/or municipal waste was analysed and used for production of light fillers for waffle or ribbed RC floor slabs (Hájek P., 2000). The research have proved the acceptability of replacement of silicate fillers by fillers from recycled materials, namely from recycled plastics and recycled laminated beverage cartoons.

The analysis of secondary raw materials with regard to their possible use as fillers in waffle and ribbed composite RC slabs was the first step of the research. Then, performance, reliability and durability of the composite structure with fillers from recycled waste materials were analysed. Special attention was given to the problem of health aspects (see chapter 3) of the new composite structure.

4.1 Experimental investigation

Several structural alternatives of composite waffle and ribbed slabs were designed, analysed, evaluated and compared. The shape of fillers was determined by the results of multicriterion optimisation with regard to environmental criteria as well as to structural parameters of the resulting composite structure. Three selected alternatives of waffle and ribbed slabs with fillers from recycled waste materials were experimentally produced and tested – Figure 4.

The fillers from recycled plastics (alt. I and III) were developed and optimised by the first author and produced by Transform Lázně Bohdaneč. Alternatives I and II were tested in CTU laboratories and alternative III was experimentally used in situ in the construction of Senior-

Centre in Moravany, East Bohemia. The experimental verification of all alternatives has shown compatibility of materials (concrete and elements from recycled waste) in the composite section during the whole service life of the structure. The suitability of further recycling of demolished composite slab structures with fillers from recycled plastics was proved by the test in the recycling crusher.

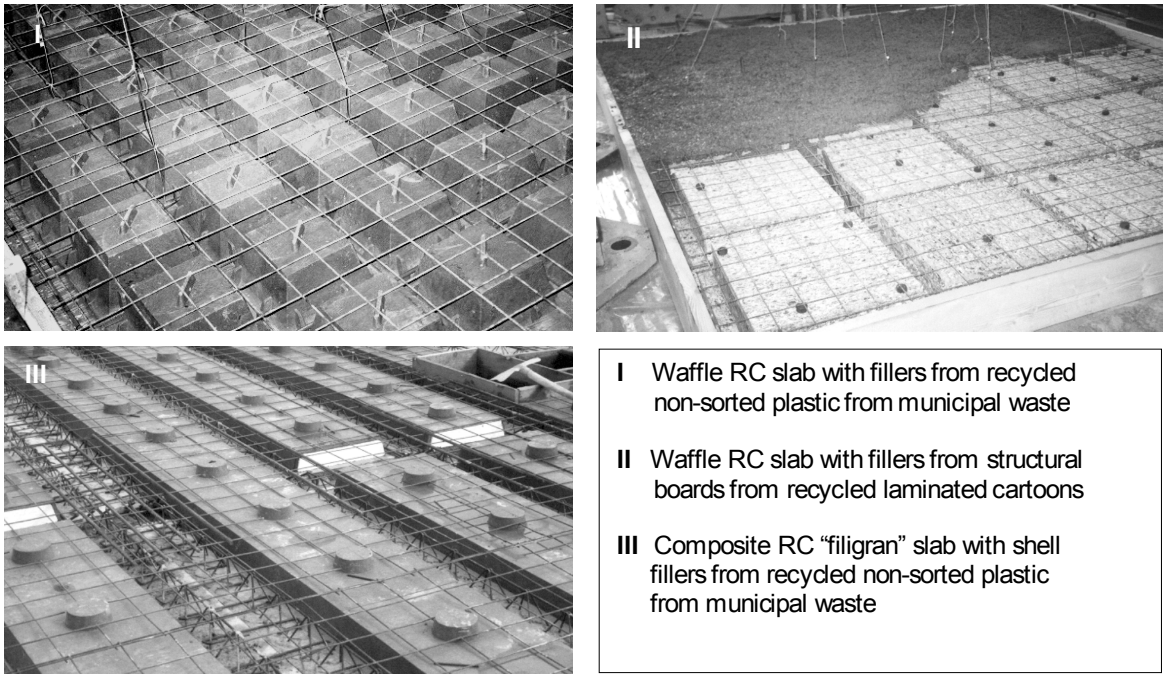

Figure 4 Alternatives of experimentally produced and tested fillers

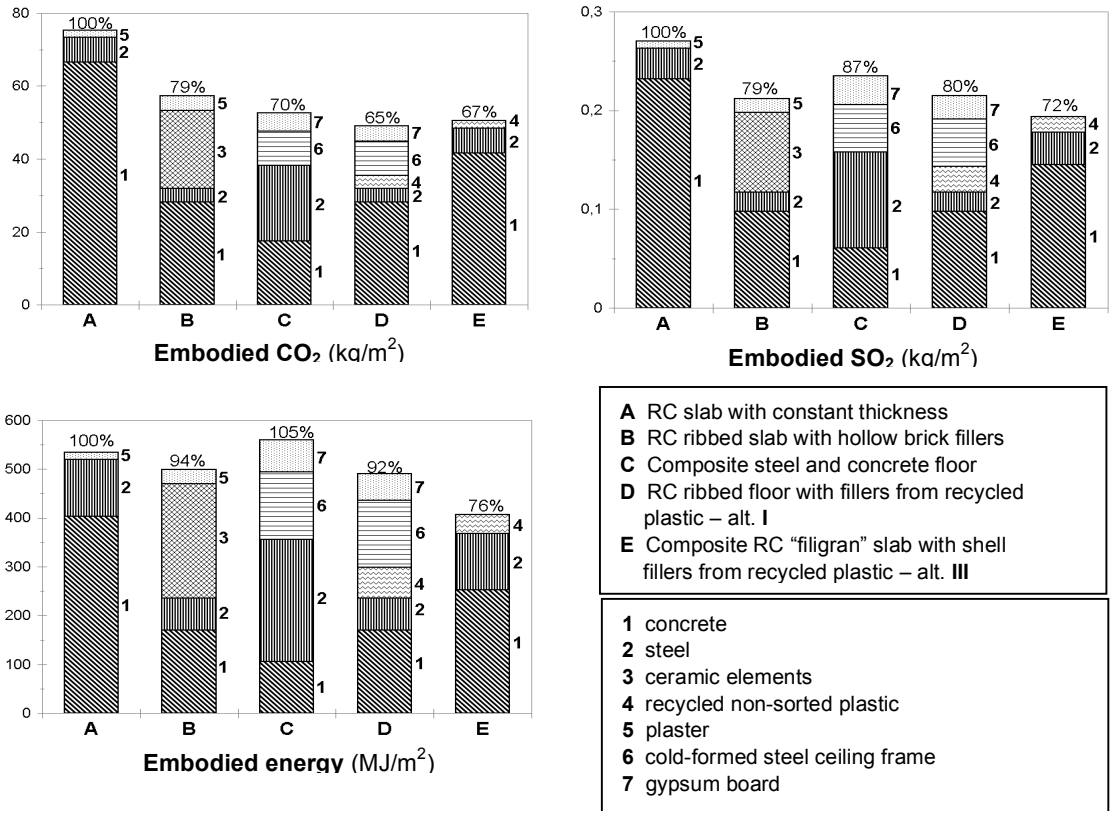

Figure 5 Comparison of embodied values of five selected alternatives of floor slabs

4.2 Environmentally based evaluation and optimisation

Five alternatives of floor slabs were analysed using data set (SIA, 1995) and compared. All alternatives were designed for an identical span and loading and they were considered with a final ceiling finish. Graphs in Figure 5 show the differences between selected alternatives assessed using different environmental criterions.

The results of the analysis show that total embodied values associated with the two alternatives of floor structures containing recycled components are in most cases lower than in the other evaluated alternatives. Essentially, it is necessary to consider reduction of environmental impact through savings in the use of primary non-renewable materials and reduction of waste disposal (especially of municipal waste).

5. CONCLUSION

The results of the long-term research have proved the possibility of the use of structural components from recycled waste in the building construction. The investigation was focused on reuse of municipal waste that is often disposed of or burned with corresponding negative impacts on the environment.

Two types of recycled waste materials (non-sorted plastic and laminated cartoons) have been experimentally tested and their suitability for the production of fillers to be used in waffle or ribbed RC slabs has been verified. Using recycled materials and the optimised filler shape, it was possible to reduce consumption of non-renewable silicate materials, the resulting production of CO_2, SO_2 and consumption of energy. The performed case studies supported preliminary assumptions about the undisputed significance of (i) the selection of materials, including recycled materials and (ii) optimisation of the shape of the structure (Hájek P., 2001).

The current research is supported by the grant GACR 103/02/1161 and grant VZ CEZ J04/98:2100001. All support is gratefully acknowledged.

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Retrofit of an urban apartment building near „Passive House“ standard (Zurich)

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INTRODUCTION

The passive solar house standard is highly relevant when it comes to new buildings. But in fact, it is possible to come near to achieving this standard in restoration projects too. In Switzerland, refurbishment and renovation projects are very important, since the majority of the existing buildings cannot simply be replaced by (passive) new buildings with a low energy consumption. Very often, the chances of achieving the aim of a passive solar building depend on the basic conditions, and, in particular, on the attitude of the client.
In Zurich, the refurbishment of a 107-year-old property due for demolition was designed to meet the passive solar house standard, despite the protected status of the building. The renovation work was carried out according to the criteria for sustainability presented in the handbook “Eco-logical Construction Practice” [1)]. It is the first refurbishment project of this kind in Switzerland.



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Figure 1 Rebuilding the attic floor with prefabricated elements

INITIAL POSITION AND CHALLENGES

Since the 107-year-old multi-residential house was in a relatively poor condition, a complete renovation was necessary. The building is located in the middle of the city of Zurich, in the 'Kreis 4' district; it stands between a building of the same height on one side and a two-storey building on the other. The street-side façade has to meet the requirements of a preservation order. Since the rear façade facing onto the courtyard is only 4 metres from the nearest building, it is subject to the corresponding planning and building regulations with regard to thermal insulation measures. The interesting challenge in this renovation project was to create high quality housing

which would attract “good” tenants to an area in the neighbourhood of Zurich's red light district. This aim has been achieved with the current tenant profile.

PASSIVE SOLAR HOUSE STANDARD IN THE REFURBISHMENT

It is difficult to achieve the passive solar house standard in any renovation project. However, when a façade has to meet the requirements of a preservation order, it is virtually impossible. The challenge presented in designing and carrying out the refurbishment is far greater, since the existing substance of the building and all its unknown quantities such as leakages, thermal bridges etc. have to be taken into account.

Apart from the installation of comfort ventilation, renovation work on the building envelope aims to achieve U values of under 0.15 W/m2 K. This means a very low heating requirement, if possible under 15 kWh/m2a NF. In this case, fulfilling the primary energy consumption at under 120 kWh/m2 a net floor area was easily achieved. In addition, however, the building envelope has to be made as airtight as possible, i.e. to achieve an air change nL_{50} value of 0.6 h^{-1}.

The decisive criteria for the passive solar house standard (for new buildings) were fulfilled, except for the building envelope and the air-tightness. The heating requirement is slightly higher because it was not possible to insulate the street-side façade more effectively. The required air-tightness was not achieved either. The whole building envelope has a nL_{50} value of about 2, with the four wood storage heaters and the basement.



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Figure 2 Before and after renovation

REFURBISHMENT CONCEPT

Basically, the original structure and configuration of the building was maintained. Although the rooms are small, the flats have a certain charm and offer high-quality space. These features were enhanced in the refurbishment. Following the principles of ecological building, as little as possible was demolished and as much as possible was retained. The existing doors, door frames, wainscoting and suchlike were restored and repainted. The attic floor, however, was in such a poor state that it had to be completely demolished and rebuilt with prefabricated wood elements.

The shape of the building displays a favourable ratio of surface areas to net floor area (A/NF = 1.5). The building envelope was improved to above average in terms of thermal insulation: the insulation layer is between 16 and 40 cm thick. About 70% of the building envelope has an average U value of 0.15 W/m2 K.

Owing to the preservation order requirements, visible changes to the street-side façade, which comprises 20% of the building envelope, had to be kept to a minimum. However, we were able to place a 3 cm thermal insulation layer both outside and inside, which meant that we reached a U value of 0.43 W/m2 K.

The remaining 10% of the building envelope consists of windows with a U value of under 0.7 W/m2 K (the U value of the glass is 0.5 W/m2 K). On the street-side, the thermal insulation of the window frames was improved by placing a soft fibreboard between the walls and the window frames. On the rear façade, the external thermal insulation was extended over the window frames.


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Figure 3 Two-bedroom-flat on standard floor

SERVICE INSTALLATIONS

Before the refurbishment, the building was heated by means of individual paraffin oil heaters and electric radiators. There was still no conventional heating system, built-in heat emitters or underfloor heating one hundred years after construction.

The aim was to keep the energy consumption for heating, ventilation and hot water as low as possible and to make extensive use of renewable energy. The energy required for heating and hot water is collected in a storage cylinder (2,600 litres) with an integrated boiler from a solar panel system (15m2) and an air/water heat pump (9 kW).

The heat is distributed via the ventilation system with heat recovery as warm air heating. Each flat has its own system unit, which can be adjusted independently.
If the outside temperature falls below -2°C, the warm air heating is unlikely to be sufficient, and the remaining requirements must be covered by the wood storage heater in each flat.

ENVIRONMENTAL POLLUTION REDUCED BY A FACTOR OF 10

Compared to the former situation, the primary energy consumption for heating, hot water, ventilation and domestic electricity has been reduced by a factor of 10. Before the refurbishment, the

primary energy consumption amounted to about 1,000 kWh/m2a net floor area; the aim was to reduce this to 100 kWh/m2a NF (electricity consumption multiplied by 2.97, oil x 1.09, gas x 1.07, wood x 1.01).

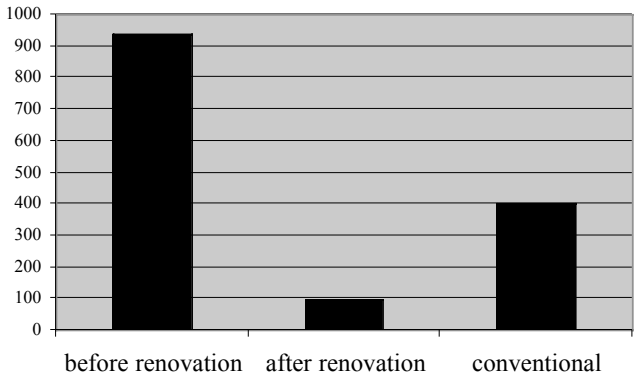

Figure 4 Primary energy consumption (PEI) in kWh/m2 year net floor area, according to „Passivehouse“ standard.

HEATING REQUIREMENT 5 TIMES LOWER THAN REGULATIONS DEMAND

The heating requirement (Q_h) is five times lower than the regulations demand. For the refurbishment on Magnusstrasse 23, the heating requirement (Q_h) limit set by 380/1 lies at 107 kWh/m2a NF, while the value planned is only 20.9 kWh/m2 a NF.

ECOLOGICAL CONSTRUCTION

A great deal of importance was attached to ecological considerations. The flow of materials (in both demolition and installation work) was kept to a minimum. The project focussed on applying the requirements of our own publications such as 'Eco-logical Construction Practice' [1)] and the SIA D0122 'Ecological Aspects of Building' [2)]. We also worked in collaboration with the Centre for Sustainable Design, Planning and Construction at the Zurich University of Applied Sciences, Winterthur.

CONCLUSION

Magnusstrasse 23 now undercuts the Minergie new building standard by a factor of 2 and the Minergie refurbished building standards by a factor of 4. In order to reach the passive solar house standard, the street-side façade would have to be insulated to the same extent as the rear façade. However, in spite of this shortcoming, it is clear that a refurbishment can reach a far higher standard than ordinary new constructions if sensible measures are taken.


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Figure 5 Interior spaces

Monitoring success
Magnusstrasse 23 will be monitored as a pilot and demonstration project over the next two years (2001 – 2003) and its performance evaluated as comprehensively as possible. The question also arises how far the passive solar house standard can function in a refurbishment.

Several factors which were taken into account in the refurbishment plans remain uncertain; for example in the ground floor flat, the effects of the thermal bridges cannot be monitored precisely, in spite of efforts to allow this. Furthermore, for privacy reasons, the inhabitants tend to close the blinds more often than expected, which reduces the anticipated solar energy gain. In order to compensate for this, they can use the wood storage heaters to generate more heat as required.

We are very interested to see what developments occur in refurbishments based on the passive solar house standard.

Project team
Karl Viridén, Viridén + Partner, Zurich
Prof. Peter Hartmann, Zurich University of Applied Sciences, Winterthur
Heiri Huber, Hochschule für Technik und Architektur HTA Lucerne
René Naef, naef energietechnik, Zurich

Sponsors
Amt für Abfall, Wasser, Energie und Luft, AWEL, Zurich
Bundesamt für Energiewirtschaft, Berne
Competair (Maico), Thalwil
EWZ Stromsparfond, Zurich
Flumroc AG, Flums
Suprag AG, Telekommunikation, Zurich

Building data

Multi-residential building	with 4 flats
Year of construction	1894
Refurbishment	April 2001
Location	Zurich
Area of plot	111.4 m^2

Area covered by building	97.8 m^2
Building envelope figure (A/NF)	1.5
Net floor area (according to passive solar building standard)	375 m^2
Architects	Viridén + Partner and Prof. W. Dubach, Arch. SIA / BSA, Zurich

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Designing a Green Apartment Building in New York City: A Case Study

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1. INTRODUCTION

The design of Twenty River Terrace is presented here as a case study of the first green residential high-rise building in New York. The project is a public-private partnership growing out a state government initiative to advance the environmental standards for buildings. This project has been an exciting, often frustrating, and always illuminating opportunity to explore our deep interest in how buildings are conceived, and how changes in building practice lead to new expressions in building design. While Twenty River Terrace has not led to a complete re-conception of what a green high-rise residential building should be, it has offered us a glimpse of the possibilities and the challenges that we can look forward to as a design firm, and more broadly, as a profession.



Figure 1: Image of the building from the west side. Rendering by: D-Box Inc.

2. CASE STUDY

2.1 Project Description

Twenty River Terrace is a twenty-seven-story glass and brick residential tower that is currently under construction in Battery Park City, a planned residential and commercial neighborhood bordering the west side of New York City's financial district, directly adjacent to the site of the former World Trade Center. Although the building was developed privately the lease terms stipulated that this be the first building to be designed under new environmental guidelines instituted by the Battery Park City Authority, the government agency that has overseen Battery Park City's development. Our challenge was to meet these new guidelines in addition to the Authority's pre-existing design guidelines, which govern everything from the building materials and window proportions to the building's orientation and height setbacks.

2.2 Overview

Our overall goal at Twenty River Terrace was to reduce the building's environmental impact during construction and over its lifetime use, and increase its energy efficiency in comparison to a traditionally constructed New York City high-rise residential building of similar size. More specifically, we faced a complex list of sometimes conflicting criteria as we set out to meet three separate goals: meeting the Battery Park City Authority environmental design guidelines (a requirement), qualifying for the recently enacted New York State Green Building Tax Credit (a financial incentive pilot program), and qualifying for a LEED Gold rating (a voluntary national green building rating system established by the US Green Building Council.) Considering that there were no other comparable projects to refer to, there was a large research component to the design team's efforts.

In meeting the environmental and energy efficiency goals, we incorporated a broad range of strategies. Natural gas absorption chillers increase energy efficiency and reduce peak electrical loads, and the design re-captures waste heat to provide hot water to the apartments. Building-integrated photovoltaic cells provide five per cent of the building's peak electrical load. A blackwater recycling plant provides treated water for use in the toilets and cooling tower as well as roof and park irrigation. The roofs are extensively planted using a continuous membrane. All interior materials were selected to reduce or eliminate off-gassing, and to maximize recycled content. Accommodations were also made for future adaptations, including setting aside a dedicated room for a fuel cell near the electrical room. While many of the design solutions taught us a great deal, I will focus on three specific examples: the exterior wall, the photovoltaic cells, and materials sourcing. These three elements perhaps best illustrate the range of issues we faced in designing this project. Some of the issues we encountered along the way were specific to building in Battery Park City, but many are relevant to all of us who work within the field of environmental design.

3. EXAMPLES

3.1 Exterior wall

What was most interesting for us as we developed a more thermally efficient design for the exterior wall was the way it forced us to adapt the design process itself. The design goals required a much larger participation by many of the technical disciplines in the early conceptual stages of design than is typical. Alternative wall designs were analyzed not only by the architects, but by the energy consultants for energy performance and condensation issues, by the contractors for schedule and constructability implications, by the mechanical engineers for systems compatibility, and by the owner for cost and payback.

Our goal with the exterior wall was to optimize its performance. We were required to be thirty-five percent more efficient than New York State energy code. Given the pre-existing design guidelines, as well as scheduling and budgetary considerations, we had to use a conventional brick and concrete block wall. The challenge then was to optimize the combined thermal performance of the masonry wall and the windows, while avoiding condensation problems arising from the humidification of the indoor air.

Before we could begin subjecting our ideas to computer modeling, the developer commissioned a mockup of a typical New York City masonry residential wall and tested it to establish a baseline, especially for air infiltration. Once we had that baseline, we then began computer simulations of many of our ideas, including different layering methods, sealant lines, window frames, and glass to come up with the most effective and cost efficient solutions. For example, we tested various windows and glass and found that the type of glass was not as critical a component in the overall performance as we originally imagined. The type of window and the frame mattered more.

Casement windows were significantly more effective than typical sliding windows in reducing air infiltration (a major factor on a riverfront setting), while cutting solar heat gain was not as clear a benefit as in a commercial building because in a residential building heat gain is advantageous in winter. The insulating value of the glass was an important consideration, but the window frames quickly emerged as greater conduits for heat loss than any change in glass could compensate for. Many of the solutions in the final design are relatively simple and low-cost methods of increasing efficiency that can easily be incorporated into the way new conventional residential
high-rise masonry walls are constructed in New York City.

3.2 Photovoltaic Cells

The installation of photovoltaic cells at Twenty River Terrace served a dual purpose. These cells, which are laminated into a piece of glass, were required to provide at peak efficiency five percent of the base building electricity. We also saw the photovoltaics as the clearest public expression that there were energy and environmental goals incorporated into the building. This strategy also interested the Authority who was trying to establish precedence for the design and building professions, to familiarize people with this new technology, and to encourage its use in new construction.

The interesting challenge for us as design architects was how best to integrate this relatively new building material into the composition of the exterior. We committed ourselves early on to using the photovoltaics as an important element symbolically in the façade, but the final design evolved considerably as were learned of their technical and cost limitations.

Because the building exposure to the south was small and often in shadow, we wanted to locate all the photovoltaic cells on the building's west façade where we had uninterrupted exposure and extra reflection off the water. First, we proposed deploying them in horizontal bands across the length of the western side. But we subsequently learned that such a design would increase the cost of the wiring, and reduce the overall efficiency of the photovoltaics. We finally chose to place the photovoltaics in two primary clusters. One cluster is vertically organized on the west façade above the entrance. The second cluster is installed on the mechanical bulkhead at the top of the building. In both cases, the photovoltaics are treated as a special, but integral, material in the building fabric, rather than an additive component. They serve to highlight the entry and express the technology of the overall building systems. Initial

estimates suggested the photovoltaic panels would be more economical to install on the mechanical bulkhead walls, but the final bidding resulted in the panels within the main façade being less expensive.

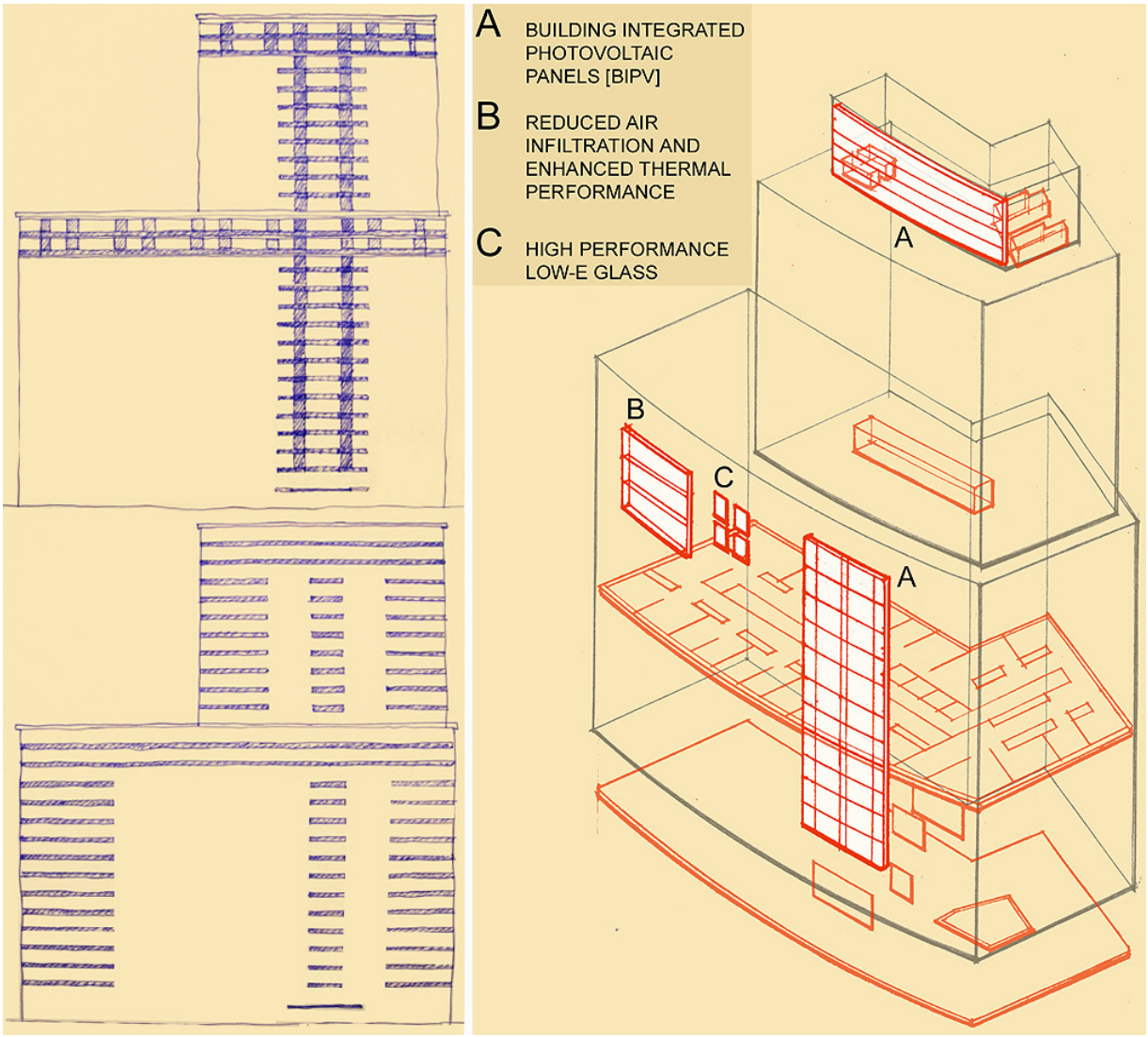

Figure 2: Diagram showing location of photovoltaic cells with two initial alternatives

3.3 Sourcing

Many of the decisions in this larger field of sustainable design involve the weighing of different priorities. This requires a level of subjective preference because it is difficult to come up with an objective measure of why one solution is better than another.

Materials sourcing was a clear example of the difficulty of coming up with an ideal solution. We were required to purchase brick from a manufacturer within five hundred miles of the project. In this case, the intention of sourcing materials within a radius of five hundred miles clearly had to do with minimizing the need for transportation. Not included in the assessment of this requirement was the relative costs of different modes of transportation and the relative environmental impact of producing the bricks at different manufacturing plants.

We found two companies that manufactured bricks that met both the Battery Park City Authority design guidelines and our aesthetic preferences. One company met the distance requirement, but used an older, less energy-efficient kiln for baking the bricks and had no access to rail transport. The other company was well beyond the five hundred mile distance requirement, but the plant conforms to the highest international environmental standards, and they can ship by train, which is more energy efficient than shipping by truck.

So the question becomes: Is local sourcing more energy efficient and better for the environment? In this case we met the sourcing guidelines, but lacked the full data to measure overall environmental impact.

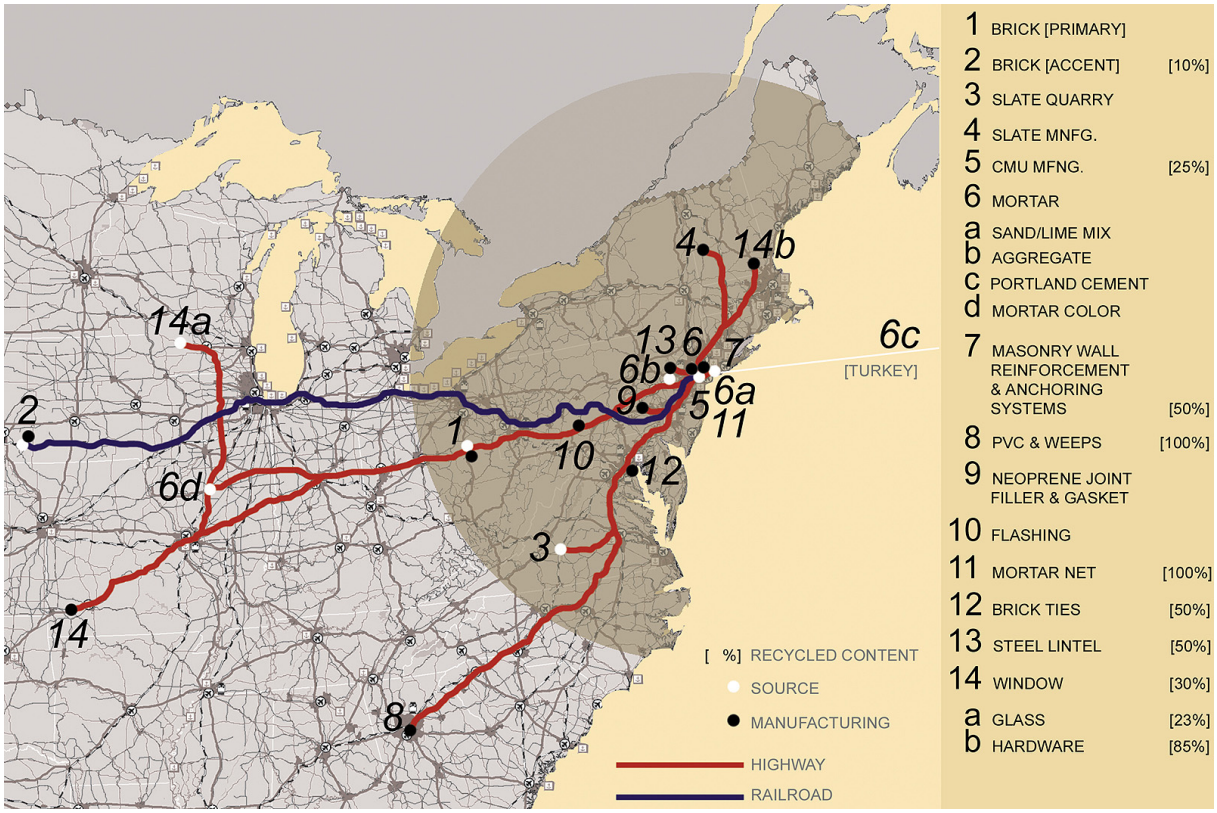

Figure 3: Regional materials used in exterior wall construction

4. CONCLUSION

Each of the three elements of the design of Twenty River Terrace that I have chosen to highlight offers a glimpse of both the opportunities and challenges we face as architects in designing sustainable architecture, particularly at a time when this industry is still in its infancy and undergoing rapid change. The policy initiatives behind this project, and the interest and effort demonstrated by the private building developer, suggest the possibility for a rapid evolution of these environmental design strategies into more broadly applicable design standards. For this to take place, though, there will need to be access to better data as a basis for comparison, further development in some of the technologies themselves and an adaptation by the building trades to ease the cost of implementing these solutions. Finally, the creative challenge remains to make architecture more than the solving of an accumulation of technical challenges. The goal of architecture must be to enrich the human experience, and the experiential qualities of architecture rely on not only the preservation of our environment, but on our participation in it.

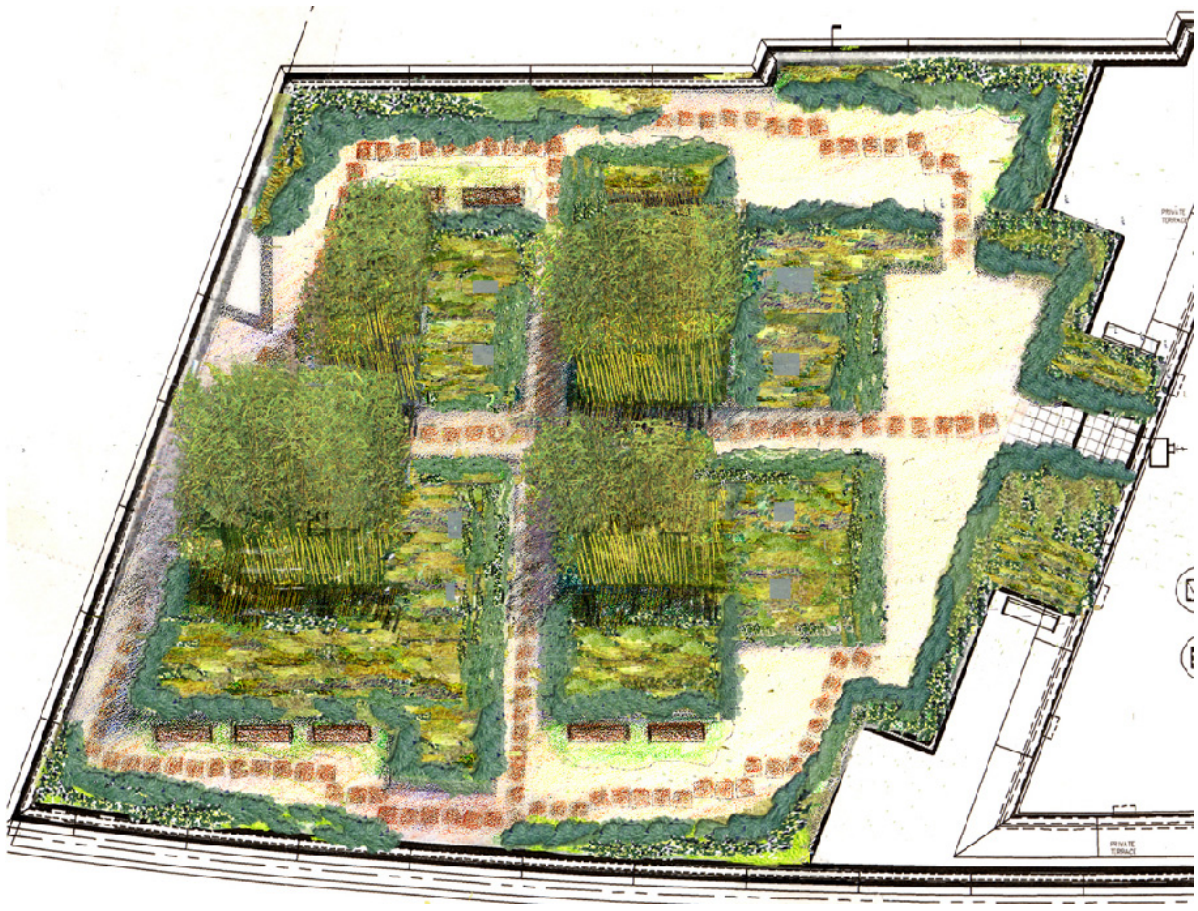

Figure 4: Terrace garden on the 17th floor. Design & Rendering: Balmori Associates

Integrated Laboratory Resource Management Strategies

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1. INTRODUCTION

1.1 Goals

This study evaluates integrated (building wide) architectural and engineering strategies for improving laboratory energy performance and resource consumption characteristics. In order to gain a broad perspective on this issue, both short and long term strategies are considered.

1.2 Methods

Strategies were evaluated using building simulation/modeling techniques. In order to measure the effects of various energy management systems on laboratory building designs, the analytical model used compares the potential effects of different electro-mechanical systems on a single "strawman" building model. System performance was tested on this building model using climatic data (TMY2 weather data) from a number of cities representing a broad range of climatic zones. Modeling was performed using Transient Simulation System (TRNSYS) for hour-by-hour analysis of thermal options.

These analyses allow general conclusions to be drawn about the benefits of various building energy systems in a number of climates, but do not address long term resource consumption issues due to inevitable renovations and reconfigurations of laboratory buildings. In order to address these issues, a parallel analysis has been conducted. This analysis compares the lifetime resource (embodied energy) consumption of interstitial laboratory facilities to those of traditionally constructed facilities.

1.3 Findings

Assuming a constant cost of energy, the benefits of building energy systems can be shown to vary as a function of specific climatic conditions. The benefits of building configuration strategies are shown to vary as a function of total building area and building longevity.

2. BUILDING ENERGY SYSTEMS – BASELINE DATA

2.1 The "Strawman" building

Built in 1988, The Biomedical Science Tower at the University of Pittsburgh has a gross area of 40,500 Square Meters (sm), including the following useable areas:

Table 1 Biomedical Science Tower Areas

Total Lab Area	12,000 sm
Total Lab Support Area	5,600 sm
Animal Areas (Vivaria)	1,015 sm
Office Areas	3,900 sm

Typical lab modules in this building are approximately 3m x 6m. There are approximately 1200 occupants in the building, yielding a gross area per occupant of 34 sm.

2.2 Model Energy Loads

These assumed loads were used during design of the structure, and appear to be equivalent to actual use values. In addition to these estimated values, it is known that the total outdoor air consumption of the structure is approximately 236,000 liters per second (lsec).

Table 2 Energy Load Assumptions

Load Type	Location	Value
HVAC Load	Offices	5.1 lsec/sm
HVAC Load	Labs*	7.6 lsec/sm
Electrical Load – Lighting	Offices	12.9 w/sm
Electrical Load – Lighting	Labs	26.9 w/sm
Electrical Load – Equipment	Offices	16.1 w/sm
Electrical Load – Equipment	Labs	172.2 w/sm
Electrical Load – HVAC	Offices	39.8 w/sm
Electrical Load – HVAC	Labs	60.3 w/sm

***Reflects use of VAV Fume Hood System**

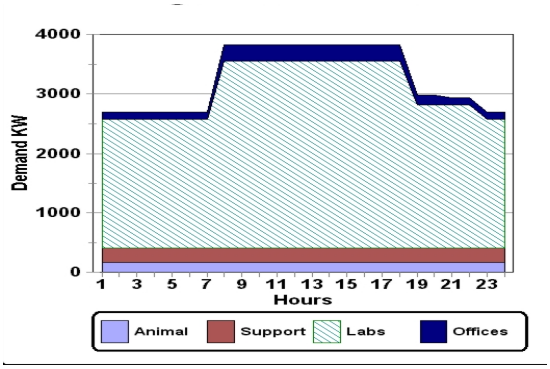


Figure 1 Schedule of Electrical Demand

These energy consumption values are assumed to be constant for all climate zones, and form the basis of comparison for the various building energy systems.

2.3 Climatic Context

In order to allow for comparative evaluation of various systems in a number of climates, system performance was evaluated in each of the following cities.

Table 4 Cities Studied – Weather Data

				Cooling Design Conditions: 1%			
	City	Heating Degree C Days	Cooling Degree C Days	Dry Bulb °C	Wet Bulb °C	Humidity (PPM)	Remarks Winter/Summer
PITT	Pittsburgh, PA	3276	341	32	22	15.7	Cold/Mild
DCSR	Washington, DC	2765	504	34	24	17.8	Cold/Humid
ATLA	Atlanta, GA	1701	864	34	23	16.1	Cool/Warm
HOUS	Houston, TX	778	1587	36	25	19.2	Mild/Hot-Humid
COSP	Colorado Springs, CO	3578	238	34	15	3.5	Cold/Dry
MPLS	Minneapolis, MN	4514	307	33	24	18.1	Cold/Hot
SEAT	Seattle, WA	2862	53	29	20	13.3	Mild/Mild
LANG	Los Angeles, CA	992	323	37	21	12.9	Mild/Mild
PHOE	Phoenix,AZ	844	1930	43	22	9.1	Mild/Hot-Dry
CHIC	Chicago, IL	3385	495	34	24	174.5	Cold/Hot-Humid

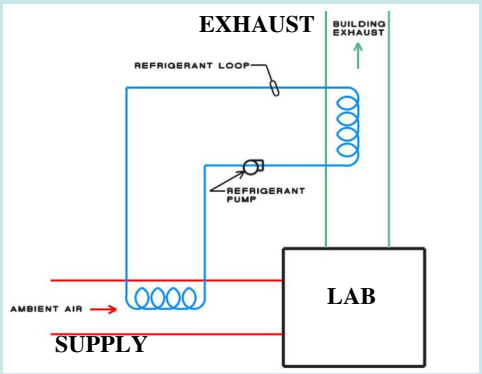
2.4 Equipment Efficiency Assumptions

A number of basic assumptions have been made regarding equipment efficiencies and power/fuel costs. For evaluation of heating systems, it is assumed that all basic heating systems will have a total fuel use efficiency of 85%. Typical gas costs associated with these systems are assumed to be $9500 per megajoule. In addition, it is assumed that electricity costs will average $.10 per kWh.

3. BUILDING ENERGY SYSTEMS EVALUATIONS

3.1 Energy Recovery System: Run-Around Refigerant Loop (Heat Pipe)

This system uses refrigerant to transfer heat between supply and exhaust air streams, minimizing inefficiencies associated with high volume exhaust streams.



System Performance: RUN AROUND LOOP

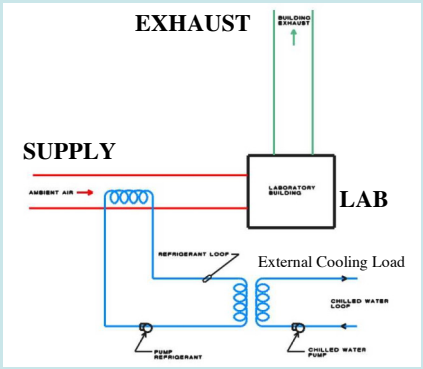
CITY	CLIMATE	Heating Energy Recovered mJ x10^6	Cooling Energy Recovered mJ x10^6	Total Annual Savings
PITT	Cold	59.14	0.29	$ 663,856
DCSR	Cold	54.19	0.57	$ 612,829
ATLA	Mild	39.74	0.70	$ 453,513
HOUS	Cooling dominated	23.69	1.65	$ 288,454
COSP	Cold	62.16	0.31	$ 697,835
MPLS	Cold	73.38	0.27	$ 822,404
SEAT	Mild	49.82	0.05	$ 556,446
LANG	Cooling dominated	26.13	0.03	$ 291,854
PHOE	Cooling dominated	22.85	5.05	$ 328,741
CHIC	Cold	63.11	0.39	$ 709,608

Figure 2 Run-Around Refrigerant Loop

As indicated in attached diagram (figure 2) this system is most effective in cold climates. Effectiveness is low in cooling dominated climates, and moderate in mild climates.

3.2 Energy Recovery System: Wintertime Free Cooling

This system uses a refrigerant loop to transfer heat between existing external cooling loads and incoming supply air streams. The system is only effective if there is a supplemental thermal load requiring chilled water year round.



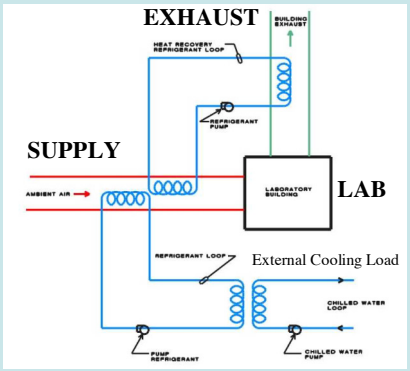
CITY	CLIMATE	Free Cooling mJ x 10^6	Hours for Free Cooling	Value/Savings Free Cooling
PITT	Cold	29	4,794	$397,396
DCSR	Cold	24	4,525	339,997
ATLA	Mild	13	3,025	175,770
HOUS	Hot/Dry	6	1,716	84,706
COSP	Cold	33	5,339	454,633
MPLS	Cold	43	5,161	595,581
SEAT	Mild	18	5,485	248,435
LANG	Mild	1	1,358	20,305
PHOE	Hot/Dry	4	1,665	53,194
CHIC	Cold	32	4,994	449,359

Figure 3 Free Cooling System

As indicated in attached diagram (figure 3) this system is most effective in cold climates. Effectiveness is very low in cooling dominated climates, and moderate in mild climates.

3.3 Energy Recovery System: Wintertime Free Cooling + Heat Recovery

This system combines the features of the previous two systems.



System Performance: Combined Free Cooling and Heat Recovery System

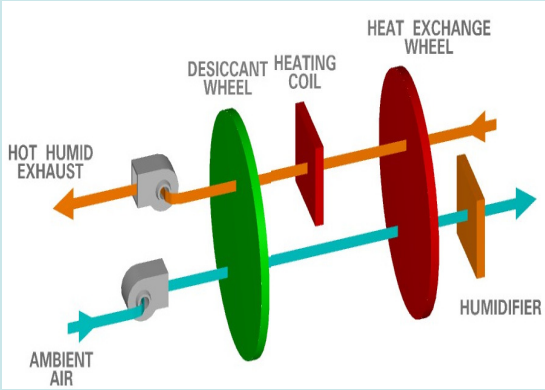
CITY	Free Cooling Energy MegaJoules (mJ x 10^6)	Heat Recovery & Free Cooling (mJ x 10^6)	Value of Free Cooling	Recovered Heat Value	Annual Savings
PITT	28.61	11.81	$ 397,396	$ 131,670	$ 529,066
DCSR	24.48	9.99	$ 339,997	$ 111,376	$ 451,373
ATLA	12.66	3.86	$ 175,770	$ 43,082	$ 218,852
HOUS	6.10	0.90	$ 84,706	$ 10,047	$ 94,753
COSP	32.73	13.30	$ 454,633	$ 148,244	$ 602,877
MPLS	42.27	18.46	$ 595,581	$ 205,882	$ 801,463
SEAT	17.89	7.00	$ 248,435	$ 78,094	$ 326,529
LANG	1.46	0.00	$ 20,305	$ -	$ 20,305
PHOE	3.83	0.00	$ 53,194	$ -	$ 53,194
CHIC	32.35	13.60	$ 449,359	$ 151,635	$ 600,994

Figure 4 Combined Free Cooling and Heat Recovery System

By reducing the difference in temperature between supply and exhaust, the free cooling system reduces the efficectiveness of the heat recovery loop. This system is generally only effective in cold climates. It is not significantly more effective than either heat recovery or free cooling systems alone.

3.4 Energy Recovery System: Desiccant Cooling

This system combines desiccant and heat exchange wheels to allow transfer of heat and humidity from the supply air stream to the exhaust air stream. Thermal energy added to the exhaust air stream allows for regeneration of the desiccant wheel. In addition, humidity must typically be added to the supply air stream to produce comfortable conditions in the lab.



Dessicant Cooling System Performance

CITY	Design Condition		Air Stream Temperature C			Cooling Provided kJ	Heat Supplied kJ	COP
	DB C	Moisture PPM	From HX Wheel	After heating	Exhaust			
PITT	32	15.7	52	82	61	28.48	34.56	0.8
DCSR	34	17.8	128	128	128	35.36	36.77	1.0
ATLA	34	16.1	125	125	125	34.65	37.76	0.9
HOUS	36	19.2	145	145	145	40.35	32.57	1.2
COSP	34	3.5	---	---	---	---	---	---
MPLS	33	18.1	128	128	128	37.97	37.76	1.0
SEAT	29	13.3	105	105	105	23.02	27.85	0.8
LANG	34	12.9	111	111	111	24.68	35.10	0.7
PHOE	43	9.1	133	133	133	26.11	19.00	1.4
CHIC	34	174.5	128	128	128	35.60	34.06	1.0

Figure 5 Desiccant Cooling System: Design and Performance Data

As indicated by coefficient of performance (COP) values greater than 1, desiccant systems are most effective in hot/dry conditions, or in systems with a ready supply of excess or inexpensive heat energy. In these conditions, total cooling provided by the system is in excess of total additional system heat demands.

3.5 Onsite Electricity Generation Systems

These systems, including fuel cells and gas micro-turbine systems, are used to provide onsite power, and have the added benefit of producing excess heat. A very high level of system efficiency can be achieved when this excess heat is used to offset other thermal loads. In addition, these systems have the benefit of increasing power reliability.

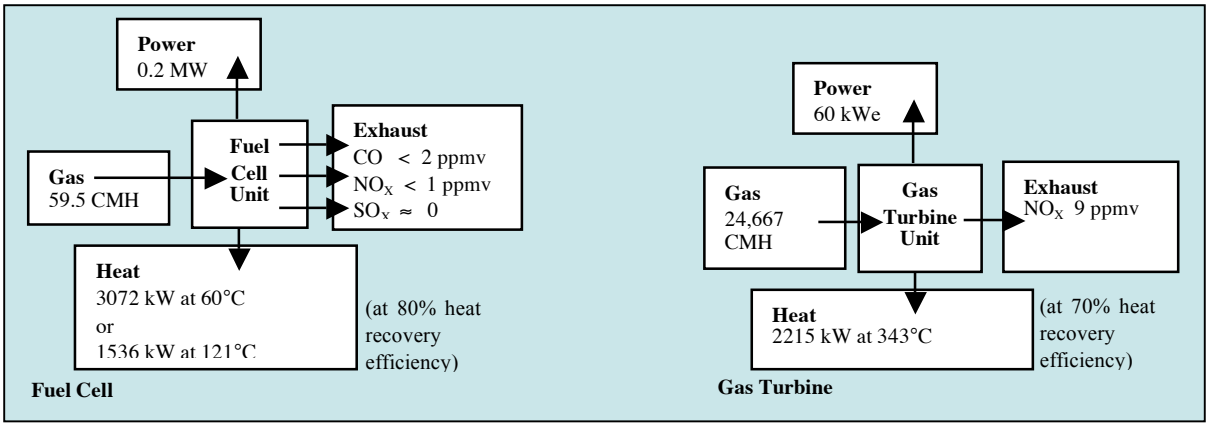


Figure 7 System Diagrams: Onsite Generation

In order to meet the demands of the test case, systems must provide 2.6 MWe of electrical energy. In the case of a fuel cell system, this results in 118,000 mJ excess heat per day. A gas turbine system would produce approximately 480,000 mJ excess heat per day.

Table 5 Onsite Generation Systems - - Potential Contribution to other Energy Systems

CITY	CLIMATE	Fuel Cell + Dessicant Cooling	Turbine + Dessicant Cooling	Fuel Cell + Service Hot Water Supply	Turbine + Service Hot Water Supply	Fuel Cell + 450 ton cooling system*	Turbine + 1900 ton cooling system*
PITT	Cold	14%	59%	1018%	4200%	20%	84%
DCSR	Cold	13%	55%	1018%	4200%	16%	68%
ATLA	Mild	13%	54%	1018%	4200%	16%	69%
HOUS	Hot/Dry	15%	63%	1018%	4200%	14%	60%
COSP	Cold	--	--	1018%	4200%	0%	0%
MPLS	Cold	13%	54%	1018%	4200%	15%	63%
SEAT	Mild	18%	73%	1018%	4200%	25%	104%
LANG	Mild	14%	58%	1018%	4200%	23%	97%
PHOE	Hot/Dry	26%	107%	1018%	4200%	22%	92%
CHIC	Cold	15%	60%	1018%	4200%	16%	68%

* double effect absorption cooling system matched to heat production characteristics of generation system

As is indicated above, these systems can contribute heat to other building systems. Given the difficulty in matching electrical demands and thermal loads, the most efficient use of this type of hybrid system will most likely be achieved through the addition of thermal storage devices.

3.6 Pollution Reduction

The reviewed systems can significantly reduce emissions associated with building thermal and electric loads. NOx reductions, given below, reflect overall system performance.

Table 5 Potential Emissions Reductions (In Metric Tons of NOx)

CITY	Free Cooling Systems	Run Around Heat Recovery	Onsite Power Generation
PITT	24	8	133
DCSR	20	8	133
ATLA	11	6	133
HOUS	5	3	133
COSP	27	9	133

CITY	Free Cooling Systems	Run Around Heat Recovery	Onsite Power Generation
MPLS	36	10	133
SEAT	15	7	133
LANG	1	4	133
PHOE	3	3	133
CHIC	27	9	133

4. BUILDING CONFIGURATION AND EMBODIED ENERGY

4.1 Resource Consumption Characteristics of Interstitial Systems

Defined by the introduction of interstitial utility floors between occupied floors, interstitial laboratory configurations can minimize disruption and resource use associated with building renovations. In addition, by shortening construction schedules, such systems have the potential to reduce energy consumption associated with building construction. Overall, these savings tend to offset the initial increase in building materials consumption associated with the addition of the interstitial floors.

Comparative Embodied Energy - 250,000 sf facility

Building Configuration	Total Embodied Energy (kJ x 10-9)	Savings Due To Increased Lifespan* (kJ x 10-9)	Lifespan Required For Breakeven (no churn)
Interstitial	10.13	3.09	30.66
Conventional	9.91	N/A	N/A
* Interstitial building lifespan = 40 yrs, conventional = 30 yrs			
** Total lifespan required to offset typical 30 yr lifespan			

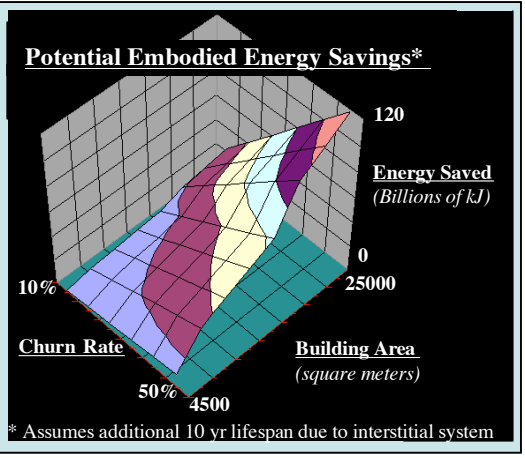


Figure 8 Embodied Energy Characteristics

A result of a comprehensive modeling effort quantifying total materials usage associated with each system, figure 8 gives an overview of potential energy savings associated with interstitial systems. Embodied energy values are based on US Energy Research and Development Administration. The illustration indicates the ability of interstitial systems to pay for themselves (in terms of overall resource consumption) in a relatively short period. With high churn rates in relatively large building areas, the overall energy savings associated over the building life with these systems can be as much as 120 billion kJ, or 5 million kWh. Reflecting both an increased lifespan, as well as savings associated with renovation materials conservation, a large structure can conserve enough energy to displace the total electric power demand in 12 houses in a heating intensive climate for the same 40 years.

5. CONCLUSION

5.1 Integrated Building Energy Systems Benefits

System efficiency is a function of specific climatic conditions. In many cases, energy savings are provided by these systems are enough to offset initial capital investments in less than 10 years. While not explored in depth in this paper, systems combining onsite electrical generation with thermal storage and 2 stage cooling systems offer great promise in terms of overall system reliability and efficiency.

5.2 Interstitial Systems: Embodied Energy Benefits

The energy conservation benefits of these systems are less than those offered by integrated building energy systems. However, over the building lifespan, the ability of these systems to reduce consumption of resources associated with renovations more than offsets the initial increase in materials consumption associated with the addition of interstitial floor areas.

Analysis of sawn eucalyptus greenness for housing production in Brazil

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1. BUILDING MATERIALS MANUFACTURING AND CHALLENGES TO SUSTAINABLE CONSTRUCTION

Building materials production is important because of its influence on economic development, but on the other hand it is a sector that impacts the environment. The impact may be presented by various ways: non-renewable resources consumption, pollution generating on production, service and materials disposal.

There are many movements around the world dealing with this issue. It has been said that developing countries should develop less than other countries, to refrain more damages to the environment caused by the American way of life appeal. Apart from the controversy on these collocations, we must change our meaning of development, since the consequences of economic based development are well known.

Particularly to developing countries, there are several issues to be discussed by sustainable development concepts. In these countries, environmental issues must be treated at the same time as social-economic and political issues. The main challenges are searching solutions to pollution and non renewable resources consumption, in harmony with social, economic, cultural and natural environment, through adapting to local labour, creating new forms of jobs, making good use of local resources, increasing building materials life span, reducing costs and making local economic development viable (BORDEAU, 1999; INO e SHIMBO, 1999).

Sustainable development concept points that it is necessary to deal with so many issues considering their interactions and recommends an integrated approach, exploring their complexity (BORDEAU, 1999).

2. JUSTIFICATION

Wood has been pointed as a potential building material that could consider the environmental principles of sustainable construction concept because it has some favourable points such as renewability, which could reduce the pressure on non-renewable resources and on native forests and carbon dioxide absorption. In the Brazilian context, there are other advantages,

like suitable climate, large areas of suitable soil to cultivate various wood species (FUNPAR, 1993). Furthermore, labour training, its improvement and the possibility of involving wood housing users in Brazilian alternative construction process, like self-help housing may be a way to recover wood construction culture (FUNPAR, 1993).

But, Brazilian forestry-based industry has some differences if it is compared to developed countries because there are technological development disparities between paper and cellulose sector and the rest of wood based sectors and this situation is viewed in its organisation. Furthermore, in the Brazilian context, wood housing is seen to be temporary house or a sign of poverty (FUNPAR, 1993), resulting in a little developed sawn wood sector.

Many problems, including environmental ones, are consequences of this situation. Challenges have been studied which are related to reforestation (LIMA, 1996; RODIGHERI, 1997), manufacturing process, drying (GALVÃO, 1976), preservative treatment (PASEK, 1994), durability (BENEVENTE, 1995) and others. The major of these researches are specified into a step of the wood processing and they are mainly related to technological issues.

These contradictions about Brazilian cultivated wood greenness show opportunities of new researches to inquiry its real greenness that could guide searching solutions to identified problems, in a better way to attain sustainable construction challenges.

3. OBJECTIVES

In developing countries it is necessary to deal with different sustainability dimensions holistically. However, analysis methods that join all the different dimensions equally are not known. It has limited the research objective, which was determined to be *analysis of sawn wood greenness from other sustainability issues.* It has defined a research about sawn wood that was based on an analysis of its production chain, which could explore different issues (social, economic, politics) influencing environmental problems.

In this research, the main problems and opportunities of Brazilian production chain were identified form the point of view of the agents of the production. The study case was limited to Rio Grande do Sul State, in Brazil, to make its accomplishment viable.

4. RESEARCH METHODS AND RESULTS

The research method was based on interviews with the agents of the production chain, and it was composed by three parts: data collection, sawn wood diagnosis and greenness analysis.

4.1 Data collection

The objective of this step was to join information about cultivated wood and sawn wood production, to better understand the local production chain. The data collection was made by Internet search, public institutes (municipal and state bureau of environment, agriculture and housing), libraries in universities and research institutes and wood industry sector syndicates and associations. Some questionnaires were devised for the interviews with the agents of the production chain.

Different companies were chosen to apply the interviews, in scale and activities, indicated by a representative of wood industry sector. The quantity of samples was not previously determined and just after seven were completed, there was no news and it was decided to stop. The interviews were composed by two parts: free – about problems and opportunities of

each company – and questionnaire – about company technical data. The free interview was considered one of the best ways to capture the interviewee opinion and allowed to reveal the interfaces among sawn wood production steps.

About this step it was possible to say:

- There is a lack of reliable data, mainly about all wood housing production chain;
- There is a lack of data about sustainability issues on production chain;
- The available research data deal mainly with problems of each step of manufacturing;
- There is a lack of researches dealing with steps interface problems and about environmental problems under sustainability view.

During the interviews, the agents talked about various problems, mainly about economic and political ones. The decreasing offer of wood and loss of wood in the form of residues are seen as problems, but not related to environmental ones. Just bigger companies mentioned environmental issues, because of export conditions to European countries. Small companies have the worst problems, like less control of raw material quality, lack of technological information. About the opportunities to develop the production chain, they talked about good climate conditions to cultivate forests, state forest inventory and the growing demand for wood products.

4.2 Sawn wood production diagnosis

It was chosen a way that could better show all the interviews richness and that could self explain and show the relationship of reasons and consequences in the results.

The explaining flow chart is a way to organise identified problems and opportunities, as "problem description" (middle), its "possible reasons" (left) and "possible consequences" (right), that can help to understand the main reasons (Figure 1). The flow chart is a simplified adaptation of "situation flow chart", graphical expression of "situation explanation", developed by MATUS (1993). The "situation explanation" is "a way to organize knowledge about a reality", based "on simplified problem generator processes reconstitution"..." so that the elements of these processes are shown systematically interconnected for generating problems and their particular characteristics".

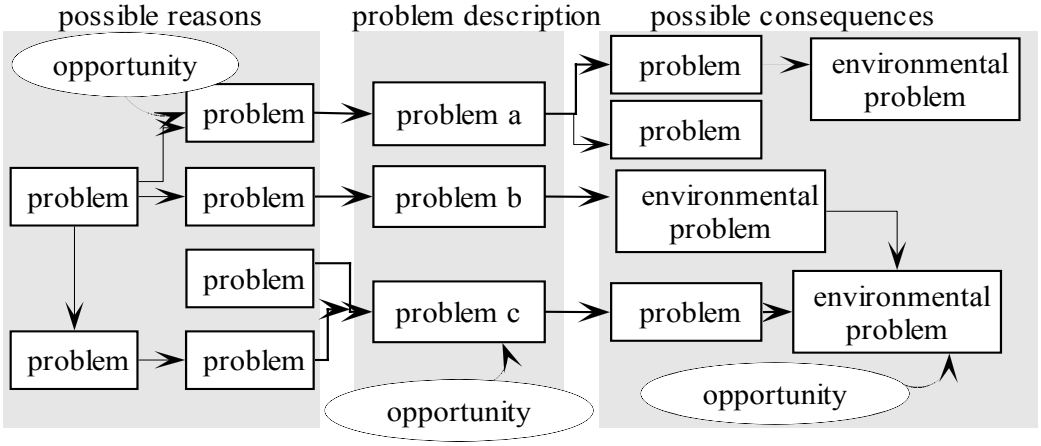

Figure 1 Flow chart structure (simplified adaptation from MATUS, 1993).

One of the flow chart generated in the diagnosis is shown on Figure 2.

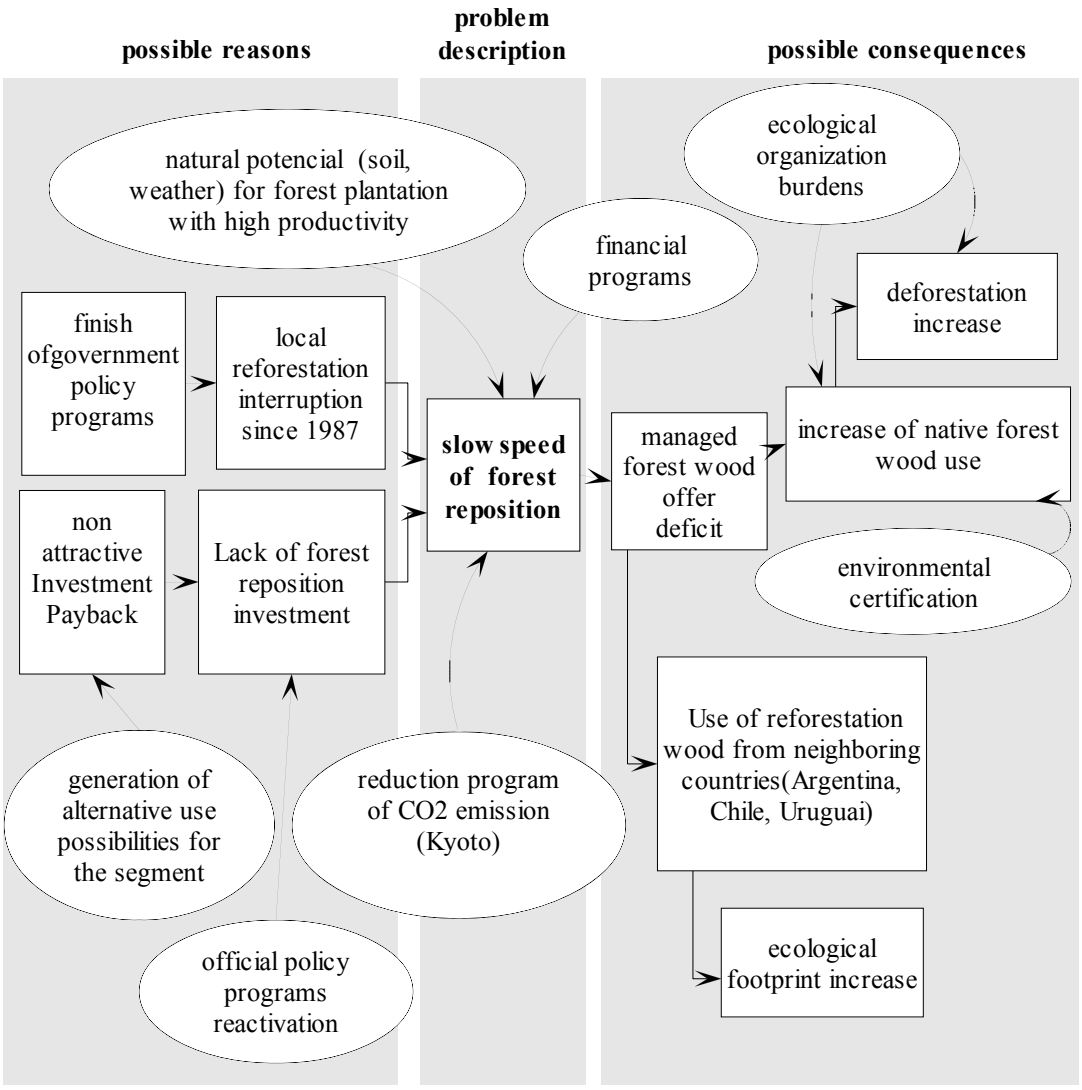

Figure 2. Sample of developed explaining flow chart: ”Reasons and consequences of low speed of forest plantation activity”

More important than identifying environmental problems, the diagnosis allowed the identification of the links among various issues that influence it. It was possible to see that most of the problems are generated in prior steps, by other problems, highlighting that it is necessary to deal with these issues globally.

4.3 Greenness analysis

In this step, the collected environmental problem data were submitted to a building material greenness analysis method to identify the reality of cultivated sawn wood.

It was used a selection of criteria of those developed by WILSON (2000) to Environmental Building News, because it is a non-quantitative data based method. The method was developed to analyse any building material and the criteria that could not be applied to sawn wood analysis were discarded. The criteria that were chosen and the reasons are presented in

YUBA (2001).

These criteria are based on environmental dimension of sustainable development concept and analyses:

- the material sources;
- its composition;
- environmental impacts caused during construction, renovation or demolition;
- environmental impacts caused during building operation;
- contributions to a safe, healthy indoor environment.

According to the criteria, presently, the critical environmental problems of production chain are:

- reduction of local managed forests wood availability;
- low efficiency in sawn wood production process;
- small added value of cultivated sawn wood;
- air, water and land pollution, caused by inadequate discard of production process waste;
- possible soil and water contamination by use of hazardous preservative treatment products;
- change of treated wood biodegradability;
- low durability caused by bad quality of design process and lack of preventive maintenance;
- discrimination of wood housing by users.

The links among these issues are different problem reasons or consequences, which act directly or indirectly on environmental problems. The analysis of the results show which economic, technological and political issues are influencing environmental problems occurrence in south Brazilian situation.

5. FINAL COMMENT

The concern to deal with production chain idea allowed to verify the main problem is lack of joining among cultivated sawn wood production chain agents – companies, users, public services, research institutions, universities - and any solution depends basically on their organisation.

In this sense, it was easy to identify the responsibilities of the agents and the importance of joined participation. Users, especially wood housing ones, are known to be little demanding according to the data collection, but at the same time, can influence significantly wood products available in the market, both by quality and by greenness and it depends on available information.

Production and mainly the diffusion of sawn wood production reliable information is a responsibility of universities, research institutions and certifiers, that could be better if developed in association with political programs to sawn wood sector and to users.

About the method, data collection should be improved, to reduce researcher influence on the answers of the interviewee. It is necessary to increase social and economic criteria through local data based researches, to develop methods that are more suitable to the Brazilian context, where these issues are more important than in developed countries.

6. CURRENT STUDY

The lack of conclusive data, that is typical of exploratory researches, is one of the barriers to develop strategies to solve sawn wood production chain problems. More effort is necessary to increase a data bank that considers a sustainability approach.

Because of results and the potential of users to influence production chain development, the subject of PhD research that is being developed, is user discrimination about wood housing. It is expected to study its reasons and identify main issues to be approached by the production chain agents to reach improvements to housing production with cultivated sawn wood.

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Energy Performance Monitoring -- Lessons Learned from the Northland College Environmental Living & Learning Center (ELLC)

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1.0 INTRODUCTION

In 1997 Northland College set out to create one of the nations most environmental student housing projects. Their results were measured and monitored by the Energy Center of Wisconsin under two separate studies. One of these studies focused on the energy and indoor environmental quality of the project. The other focused on the process of designing a green building. This paper will focus on the lessons learned from the design and construction of this project.



Figure 1 Wendy and Malcolm McLean Environmental Living & Learning Center (ELLC) at Northland College. Ashland, Wisconsin USA

1.1 Background

Northland College is a small, private, environmental liberal arts college located near the shores of Lake Superior in Ashland, Wisconsin. Lake Superior represents approximately 10% of the worlds freshwater. Many of Northland's students come there for the environmental studies program.

Northland College involved students, faculty and staff long before they engaged design professionals for their project. Once the design team was on board, this "team of owners" stayed with the project throughout the design and most of the construction process. This single fact contributed more to the success of creating a "high-performance" building than any other item.

2.0 GOALS & RESULTS

After setting goals for the project, a unique, one page "Memorandum of Understanding," noting all of the major project goals was created by the project architect and signed by all key stakeholders. The key stakeholders were the college administration, faculty/staff representatives, student organization representatives, design team, and the primary contractors. This document was bound in construction specifications (unsigned) and posted around the project site, once signed, for conspicuous exposure.

The American Institute of Architects' Committee on the Environment recognized this project as one of the top-ten most environmentally responsive designs, for Earth Day 2000.

2.1 Building Form

The building form had an impact on energy performance. The linear form with many windows while providing light and fresh air, also provided a shape with a high amount of exterior walls. Only part of the building was able to take advantage of a solar (south) orientation due to site restrictions.

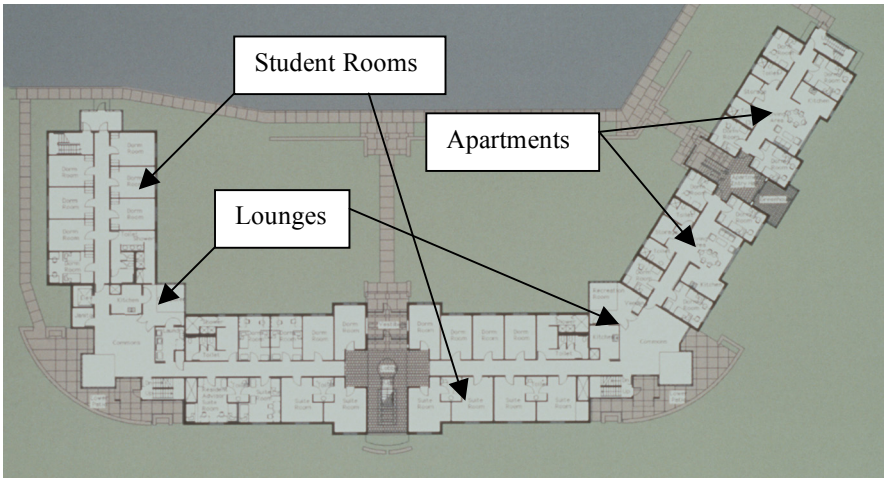

Figure 2 First floor plan of the ELLC

Total gross space was 39,994 square feet (3,715 square meters). This design included traditional double occupancy rooms, suites (with a shared bathroom), 4 apartments (for up to 6 persons) and common area lounges, seminar rooms, laundry/toilet facilities and small kitchens. Total occupant load is 114 persons.

2.2 Energy

The energy goals were established using DOE 2.1 energy modeling software to model options and alternatives under consideration. Once the loads were fixed, opportunities were explored. Some of the energy saving strategies chosen were:

- High efficiency gas boilers/heat recovery ventilation
- High efficiency light fixtures with occupancy/daylight sensors
- Consciously omitted air conditioning
- High performance glazing
- Careful detailing/construction commissioning of insulation/vapor retarder installation

Energy modeling projected a building that would operate at 40% below the level allowed by the current (1997) Wisconsin Energy Codes.

Renewable energy ideas brought forth by the students were added to the energy strategies above and included:

A 20 Kw Jacobs wind turbine
Solar domestic hot water heating
Three tracking 1.2Kw photovoltaic panels
Composting toilets for 2 of the apartments

These additional strategies were not modeled, but hoped to contribute another 10% beyond the code level building. Actual measured results over a one-year study reveal that the building is operating at 54% better than a energy code complying building.

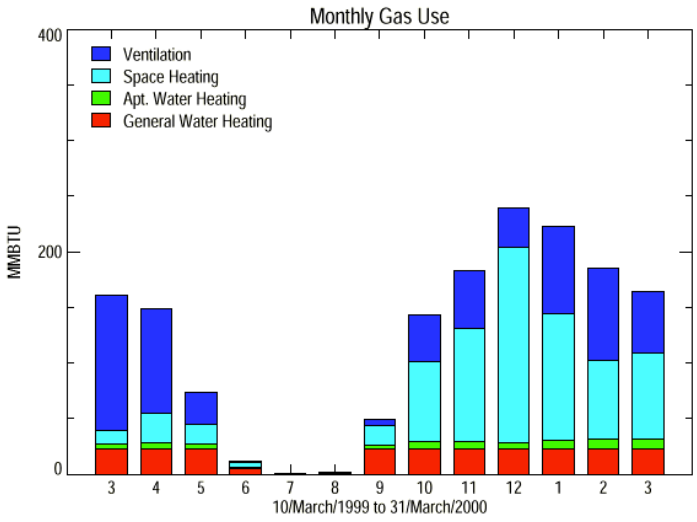

Figure 3 Monthly gas use (*source* CDH Energy Corp.)

Other energy monitoring data includes the following results:

- Electricity use is 4.7kWh/sq ft (186,600 kWh) annually.
- Fuel use is 35mBtu/sq ft (14,200 therms) annually.
- Total energy savings amounts to over $10,000/year.
- Goal: 65,000 BTU/sq ft
- Results: 51,500 BTU/sq ft

These total energy values expressed in BTU/square foot, are in the lower 15% when compared to similar facilities across the USA[2].

Renewable energy contributions were measured as follows:

- Utility provided 93.5% of electricity used at site
- Wind and photovoltaics (PV) supplied 6.5%.
- Wind turbine operated at 6% capacity factor and achieved 40% efficiency (max. efficiency of ideal wind machine is 59%)
- Occupants use 43% of all site energy.
- Solar water pre-heat provided 29% of water heating energy for the 4 apartments.

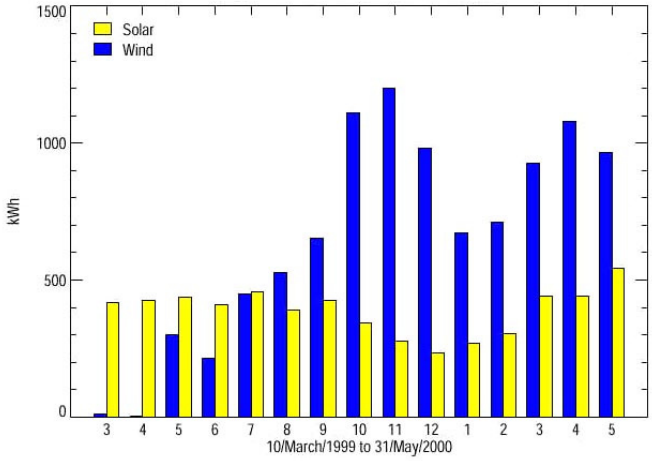

Figure 4 Solar PV and wind contributions as measured.

Based on the estimated additional costs for all green building components (primarily energy related) of $150,000, simple payback is 7.93 years.

2.3 Indoor Environmental Quality

Materials selected for this project were carefully considered for their potential off-gassing of volatile organic compounds (VOC's) and their potential "sink" effect. Beyond that concerns over the ability to be recycled and percentage of recycled content were considered simultaneous with durability and long-term maintenance requirements.

Some of the materials chosen were linoleum for student living quarter's floors in lieu of carpet. Students often bring in area rugs, which are portable, easily aired out, and typically removed at least once every school year.

Low and No-VOC paints and finish coatings were selected to benefit the applicators and the environment in general. Operable windows were selected to give occupants some amount of control over their environment. Smoking is not allowed anywhere in this building. The owner uses natural cleaning supplies for janitorial services.

Indoor air quality sensors installed include CO_2, VOC and humidity sensors. Results indicate that the indoor air quality is very similar to outdoor conditions (northern Wisconsin rural setting—very high quality).

3.0 COSTS

The total project cost for the ELLC was $108 (USD) per square foot (1998)
The national median student housing project cost in 1998 was $112 (USD) per square foot[1].
The actual construction cost (not including financing, design fees, furnishings, and legal fees) was $92 (USD) per square foot.

All renewable energy systems together cost $156,000 (USD).

4.0 LESSONS LEARNED

As stated above, the single most important lesson learned was the lesson of inclusion, participation or involvement. The college's choice to involve students and faculty early proved to be helpful in following through on their commitment to build a "green" building.

Other lessons include the building form or mass and site orientation could have had an even larger impact on the energy performance if the site space would have allowed it. More of the building with a solar orientation would have been helpful in this colder region of the U.S.A.

The public/private partnership with the Energy Center of Wisconsin providing the funding that led to the energy-monitoring project led by CDH Energy. This monitoring project led to the discovery of some mechanical equipment shortcomings. Constant volume fans provided too much ventilation and consumed more energy than necessary. Variable speed drives installed after occupancy maintained air quality while reducing energy consumption dramatically.

While the wind power, and other renewable energy systems will not have a financial payback they seem to be having an educational impact. The environmental impact of avoided emissions begs the question: What is the cost or value of cleaner air to breathe?

5.0 REFERENCES

[1]Source: *American School and University* Magazine, July 2001, annual student housing issue

[2]Source: Commercial Building Energy Consumption Survey (CBECS) 1995, www.eia.doe.gov/emeu/cbecs/contents.html

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Energy Center of Wisconsin, www.ecw.org
CDH Energy, www.cdhenergy.com
LHB Engineers & Architects, www.lhbcorp.com





Figure 5, 6 The Environmental Living & Learning Center project interior and exterior

Energetic and Environmental Profile of a Building Material: a Case Study on Sicilian Tuff

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1. INTRODUCTION

In the last years the new environmental issues have deeply changed planning practices in the building sector and the way of selecting building materials. Energy management must balance justifiable energy demand with appropriate energy supply, coupling the energy conservation, and energy efficiency with the use of primary renewable energy resources. The requirement of environmental sustainability has to be referred to the life cycle of each building component, as regards to the following steps: (1) raw materials extraction; (2) production; (3) transport; (4) end-use; (5) reuse and/or recycling; (6) final disposal (Ryding, 1999).

Despite the Life Cycle Assessment of buildings involves a high degree of complexity, it is necessary to calculate the energetic and environmental performance of building materials, in order to evaluate the ecological effects and to assume the environmental items as suitable supports for multi-criteria decision making approaches (Beccali *et al.*, 1997a).

In this paper the eco-profile of tuff is presented, referring to a sicilian firm. The Authors assess energetic and environmental performance of tuff and its production cycle. Extraction of resource, consumption of energy and environmental releases are estimated, carrying out energy and mass balance in the inventory step.

The aim of this study is to provide a suitable tool in aid of decision-making, in the comparison among alternative materials and/or for the technological improvement of the production system.

2. METHODOLOGY

2.1 Aim of Study

The eco-balance of tuff is carried out, according to the following steps: (1) Goal Definition; (2) Detention of functional unit and system boundary; (3) Inventory Analysis; (4) Sensitivity

Analysis; (5) Classification. In particular, the eco-profile of tuff block is performed (size 16x45x27 cm and weight 26,78 kg).

2.2 Goal Definition

The aim of the analysis is to assess the energetic and environmental performances of tuff, identifying the energy consumptions and suitable technogical improvements in the production process. The life cycle assessment is limited to the extraction and production of tuff and any comparison among replaceable materials is not carried out.

2.3 Functional Unit and System boundary

The selected functional unit[1] is the number of tuff blocks in a square metric of wall and all the outcomes of analysis are referred to it. In particular, resources inputs, such as the consumption of electric power, diesel oil and lubricants, and outputs, as solid wastes, sands, and air emissions, are estimated for the inquired firm, but no consideration is made about the impacts induced on the local context.

From a methodological point of view, analysis is limited to the extended technological level. In fact, the correlated processes are also included to make available the economic inputs, which are required for the main process. Resources consumption and environmental releases are estimated for fuels, power energy, and raw materials, which are required by the main process. The transport of materials from quarry to manufacturing place, the extraction process and transport of fuels, and production cycle of machineries haven't been considered.

Figure 1 shows the flow sheet of the tuff production process that takes place in the examined firm, in order to have an overview of the overall production cycle and of the other referred activities. In this figure the inside transport is included as relevant source of resource consumption and air emission.

2.3. Quality and origin of data

Data have been collected by in-field enquiry and sector bibliographical references. In detail, the analysis is essentially addressed on calculating the following items:

- Environmental and economic inputs/outputs in the tuff life cycle (Figure 2): (1) consumption of electric power by cutter-machines; (2) consumption of lubricant[2] by the different mechanical plants, such as cutter-machines, lorries, and shovels; (3) consumption of diesel oil by transport and placing of tuff blocks inside the firm.
- Variation in the specific values of energy consumption between the inquired firm and the in the regional context.
- Comparison among the different eco-profiles.

The eco-inventory of 1 MJ of electric power is derived, referring to the three following databases:

- The UCPTE 90 model (AA.VV., 1994).
- The I-LCA model (ANPA, 2000)
- The global UCPTE 90/I-LCA database model (ANPA, 2000).

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[1] The functional unit represents the reference, by means of which the collected data are normalized and to which the analysis outcomes are referred. Its definition has to be consistent with the function of the examined system and it can be seen as an index of the system performance.

[2] The data on air emissions are available, referring to extraction and distribution processes to users. Instead, the lubricants use by mechanical means are lacking.

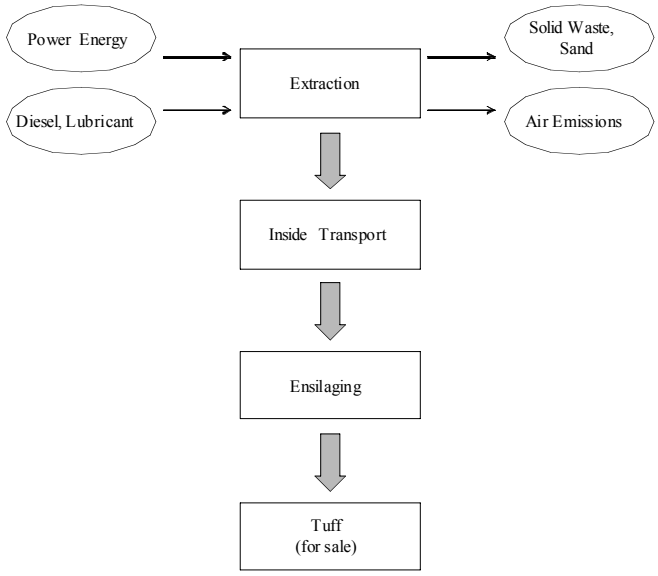

Figure 1 Flow sheet of the tuff production process

2.4 Inventory Analysis

After the data collection, the extent to which the process occurs, or the process tree, is defined (Figure 2).

The Life Cycle Assessment of a building material should include each transformation step from raw materials extraction to disposal. It is possible to analyze all the energetic flows and environmental impacts step by step, until the manufacture of end-product that is "from cradle to gate". The further stages that occur during the end-use and disposal are covered by a high level of uncertainty and could not be object of a detailed analysis.

In the inventory analysis the required energy and material resources, and the environmental releases are estimated. In Figure 3 the mass balance is shown, referring to the extraction step of the functional unit, while in Table 1 energy inputs are reported.

Resources consumption and emissions are calculated and the energetic and environmental profile is obtained for tuff, referring to each used database. The relevant items to the environmental impact have been classified according to the following criteria (Heijungs, 1996), as shown in Table 3:

- Abiotic resources depletion (1/reserve)
- Consumption of primary energy (GER)
- Global Warming (GWP_{100})
- Photochemical smog (POCP)
- Nitrification (NP)
- Acidification (AP)
- Human Toxicity (HCA, HCW, HCS)
- Eco-toxicity (ECA, ECT)
- Odour (1/OTV).

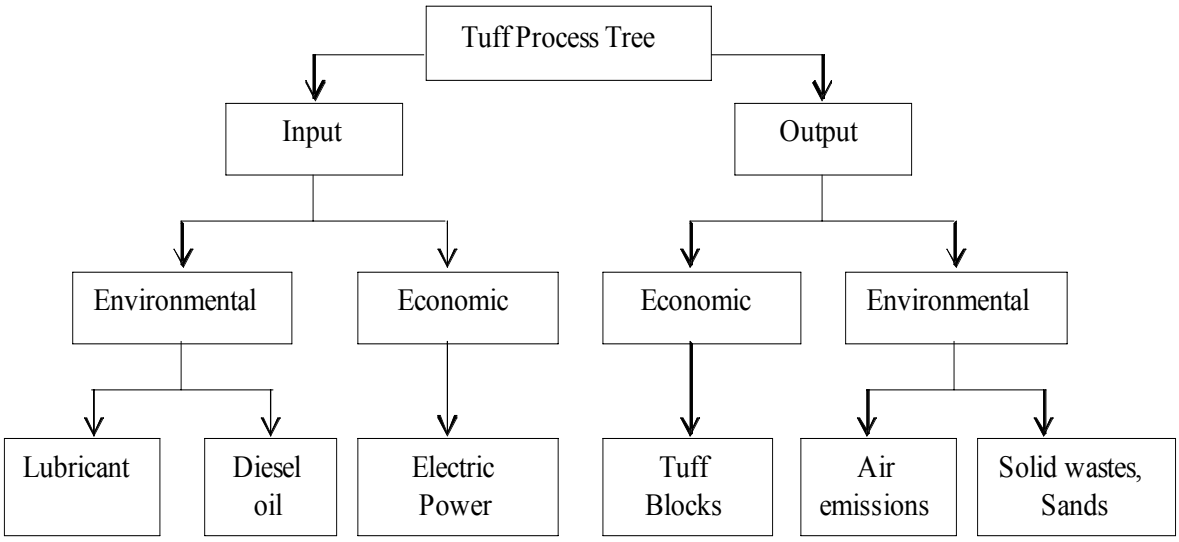

Figure 2 Process tree of the tuff blocks production.

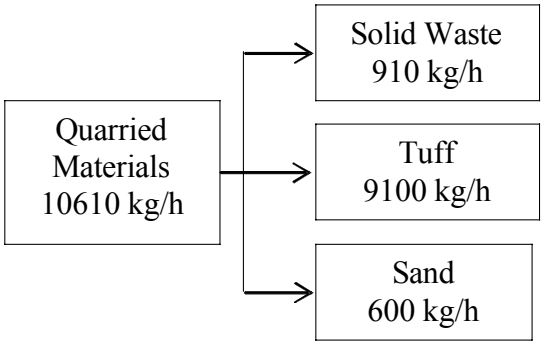

Figure 3 Mass Balance in the extraction process

Table 1 Energy consumption per functional unit.

Power Energy [MJ]	Diesel [MJ]
2.4	4

The matrix method is used to calculate the inventory table (Table 2) (Beccali *et al.*, 1997b).

Table 2 Ecobalance of tuff per functional unit.

	UCPTE 90	I-LCA	UCPTE90/I-LCA
Resources (kg)	4.15E+03	2.40E+02	1.60E+02
Air emissions (kg)	2.23E+03	1.52E+02	1.52E+02
Water releases (kg)	7.38E+01	5.24E+01	6.27E+01
Solid wastes (kg)	4.38E-03	5.57E-03	4.80E-03

Table 3 Calculation of the classification factors per functional unit.

Classification factors	UCPTE 90	I-LCA	UCPTE90/I-LCA
(1/Reserve) [yr^{-1}]	2.57E-03	7.89E-04	4.06E-04
GER	1.50E-01	3.19E-01	2.03E-01
GWP_{100} [kg]	1.99E+01	4.45E+01	3.97E+01
POCP	1.96E-04	4.52E-04	3.71E-04
NP	4.80E-03	2.63E-04	1.77E-04
AP	1.90E-01	4.80E-02	2.50E-02
Human Toxicity	4.94E-01	5.05E-02	4.05E-02
ECA	5.08E-05	5.26E-06	6.70E-06
ECT	1.36E-04	3.46E-05	4.08E-05
1/OTV	1.20E-05	8.67E-05	8.57E-05

2.5 Sensitivity Analysis

Sensitivity analysis is carried out in order to assess the tuff eco-profile variation, modifying the primary data. It depends on the linearity of the aggregation model used for the inventory matrix, so that the effect of each factor can be considered independent from the others.

In general, sensitivity analysis is performed when specific mean data of energy consumption are available at national scale. In this study, for the lacking of national databases of the needed data about the above process, the representativity of the analyzed firm is evaluated in the regional context. Available data are collected, referring to quarrying process at a regional scale. That gives the possibility to carry out the sensitivity analysis in order to quantify the variation induced on tuff eco-profile, varying original data. Referring to the regional mean specific values for the consumption of electric power, diesel oil, and lubricant, the Authors estimate the numerical variations on the energetic and environmental balance of tuff, induced by the mean regional data, compared to data of the examined firm. Table 4 shows the comparison among the inventory matrices, which are calculated for the three data sources. Outcomes show minimum differences among the two eco-profiles.

4. CONCLUSIONS

In the last years energetic efficiency is becoming one of the most relevant factors for environmental profile of buildings materials, together to raw materials and energy consumption, and waste generation. The need of environmentally oriented systems in the production of building materials has to be considered more relevant, referring to the quantitative of building sector at national level.

In this paper the ecobalance of tuff has been presented, depending on the widespread use of such material in buildings. The Life Cycle Assessment has been carried out by means of matrix method, in order to take into account the different processes correlated to the main one that influence the energetic and environmental performance of tuff.

Sensitivity analysis has made possible to estimate the numerical variation induced on tuff ecobalance, changing the primary data. Besides, an environmental improvement of tuff

Table 4 Comparison between the matrix inventory of tuff in the examined firm and the regional one

		Examined Firm	Regional Scale	Numerical Variation
UCPTE 90	Resources (kg)	6.42E+03	5.17E+03	1.25E+03
	Air emissions (kg)	6.42E+02	5.15E+02	1.27E+02
	Water releases (kg)	1.42E+01	1.11E+01	3.10E+00
I-LCA	Resources (kg)	2.32E+02	2.40E+02	8.00E+00
	Air emissions (kg)	8.84E+01	9.08E+01	2.40E+00
	Water releases (kg)	1.78E+01	1.79E+01	1.00E-01
UCPTE90/I-LCA	Resources (kg)	4.37E+02	4.52E+02	1.50E+01
	Air emissions (kg)	1.39E+01	1.42E+01	3.00E-01
	Water releases (kg)	1.81E+01	1.82E+01	1.00E-01

ecoprofile could be reached, by means of the substitution of the diesel oil with methan. In fact, such fuel could determine the reduction of the resources consumption and of the environmental releases.

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Market Introduction of Low Temperature Heating Systems in The Netherlands (status report)

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1. INTRODUCTION

Pursuing sustainable building requires sustainable solutions for heating of buildings as well. To realize energy conservation and CO_2-emission reduction objectives, a shift towards the use of low valued energy from residual and renewable sources is necessary. This requires lowering design temperatures of heating systems in commercial and residential buildings. NOVEM, the Dutch national Energy Agency, has been carrying out a programme aiming at the introduction of Low Temperature heating Systems (LTS) as a standard in the Netherlands.

Lowering the design temperature on the heat production side pursues a large saving of primary energy. Application of all sorts of energy-efficient or renewable heat producers and sources is possible. Within buildings this means the need for heating systems with a design supply temperature that is limited to a maximum of 55°C. Although widespread application of these so called Low Temperature heating Systems (LTS) has an enormous impact on the installation and building branch -which in the Netherlands traditionally is used to heating systems with much higher design temperatures (90°C)- , this change is necessary in order to achieve the national objectives for energy conservation and emission reduction. Without the possibility of using low valued energy, achieving the national objectives for energy saving and emission reduction seems impossible.

2. A NATIONAL IMPLEMENTATION PROGRAMME FOR LOW TEMPERATURE SYSTEMS

A broad implementation and application of LTS asks for the development and execution of an approach plan on a national level. This plan needs to state, which bottlenecks have to be resolved, how further experiences with LTS can be gained, and which knowledge transfer activities have to be carried out at what time. In 1996 the outlines for this plan were drawn up, and a year later NOVEM, the Dutch national Energy Agency, started a programme to introduce low temperature systems in the Netherlands. This programme, which aimed to prepare the Dutch market for a broad application of LTS in new dwellings and buildings, has been focussing on the following tasks:

Embedding

Working on an attitude-change of relevant actors in the market, and using official directives on different levels, activities within this task should lead to the embedding of the application/ utilization of LTS in daily practice. One of the first results accomplished is that LTS are now rewarded in the Dutch Energy Performance Standard. Furthermore producers of heating systems have been united in an association to promote the use of LTS.

Financing
The aim of this task is to reduce the additional costs of LTS, and to neutralize any financial barriers. As a result of these activities from the year 2000 on, eco-tax funds are available for private house owners applying LTS, and beneficial tax measures were introduced for owners of commercial buildings.

Knowledge
In order to supply all parties involved with the knowledge which is required to implement LTS in its different stages, activities are carried out within the following four subtasks:
- demonstration
- development of knowledge (e.g. IEA ECBCS Annex 37; more info at (IEA, 2002))
- development of tools, guidelines, standards etc.
- dissemination

3. LARGE SCALE MARKET INTRODUCTION OF LOW TEMPERATURE SYSTEMS

Because of the success of the implementation programme, which so to say paved the way for a massive introduction of LTS, Dutch government decided to start a follow-up in 2000. This market introduction programme for LTS aims at large-scale market penetration of LTS in new as well as in existing buildings.

The market introduction programme was intended to run until the end of 2003, and within its framework application of low temperature heating systems will be supported in over 9,000 new dwellings, in projects of at least 50 dwellings, to create maximum effect. These projects will be spread over the country, and also over different types of dwellings (apartments, terraced, semi-detached, detached houses, etc). Different types of LT-heating systems will be applied, in combination with all kinds of heat sources (from conventional condensing gas boilers to renewable heat sources and waste heat utilisation).

The programme will also focus on existing dwellings, starting off with an implementation phase, which will tackle specific problems, and identify specific opportunities related to application of LTS in existing buildings. Shortly after that a market introduction will start for existing buildings as well, aiming at over 15,000 existing houses in over 150 projects to be equipped with low temperature heating.

Apart from these 9,000 new, respectively 15,000 existing dwellings, a considerable spin-off is expected, as these projects will act as examples of a new way of designing heating systems, and people will be able to experience the advantages of LTS directly.

Meanwhile NOVEM will continue to support the market introduction with implementation actions focussing on embedding of LTS, providing knowledge, and awareness campaigns. The final aim is that LTS will become standard in new buildings in The Netherlands by the end of 2003, and by the same time applied in existing buildings whenever possible.

Recent monitoring (de Vries, 2001) shows an increasing trend in the yearly number of dwellings being equipped with LTS. In 2000 the number of dwellings, equipped with LTS, or under construction has increased by almost 10,000, already showing the spin-off of the market introduction programme. Although most LTS are still to be found in the more expensive segment, compared to 1999, the year 2000 has shown a major increase (53%) in

application of LTS in social housing, numbers almost equalling those in the private (more expensive) segment. An interesting point is that the type of LT-system applied in almost half of the social housing is floor heating, a LT-system with specific advantages for the indoor environment.

4. LOW TEMPERATURE SYSTEMS AND QUALITY OF INDOOR ENVIRONMENT

In addition to the benefits for the 'outdoor' environment, low temperature heating systems appear to have crucial advantages for quality of the indoor environment as well.

An extensive literature survey on qualitative aspects of LTS (Eijdems and Boerstra, 1999) has shown that for the end-user LTS have major advantages in terms of thermal comfort, indoor air quality, and safety, compared to traditional Dutch heating systems. Our experience is that it's just these qualities that appeal to the public at large, and therefore will be crucial for a successful large-scale introduction of LTS. In this way LTS provide a perfect combined carrier towards a sustainable energy-infrastructure, as well as a new generation of healthier buildings.

An occupants survey among people living in dwellings with a low temperature heating system has been carried out in 2000 (de Vries and Silvester, 2000). The survey covered 408 dwellings in 11 projects spread over different parts of The Netherlands. The LT-heating systems applied in these projects were floor heating, wall heating, and LT-radiators. Different heat sources were involved, ranging from condensing boilers, to heat pumps, and district heating.

The advantages and disadvantages, mentioned by the occupants in this survey are matching the results of previous researches. This survey also confirms the results of the literature review (Eijdems and Boerstra, 1999). Especially the reactions of the occupants about the perception of indoor air quality, thermal comfort, slowness and controllability of some LT-systems confirm previous studies.

Except for the controllability, occupants have a good appreciation for all LT-systems. In particular indoor climate has improved much in dwellings with floor and wall heating compared to previous situations (Figure 1). For LT-radiators there is no difference in appreciation of the indoor climate in relation to their previous situation.

A recent survey (Winter, 2001) in a project of 54 dwelling with wall heating confirms the appreciation of occupants for the LT-heating system. The large majority of the occupants is pleased by the quality of the indoor climate, and 96% would choose wall heating once again; 92% would recommend it to their friends. However, the survey also shows that the quality of the realisation process during design and construction of the heating system was quite poor. Many problems had to be solved when the dwellings were already occupied. Although the problems were solved eventually in this case, generally this can cause a negative effect on the acceptance of LTS. For that reason quality assurance and commissioning of the realisation process of LTS should be a major concern in every project.

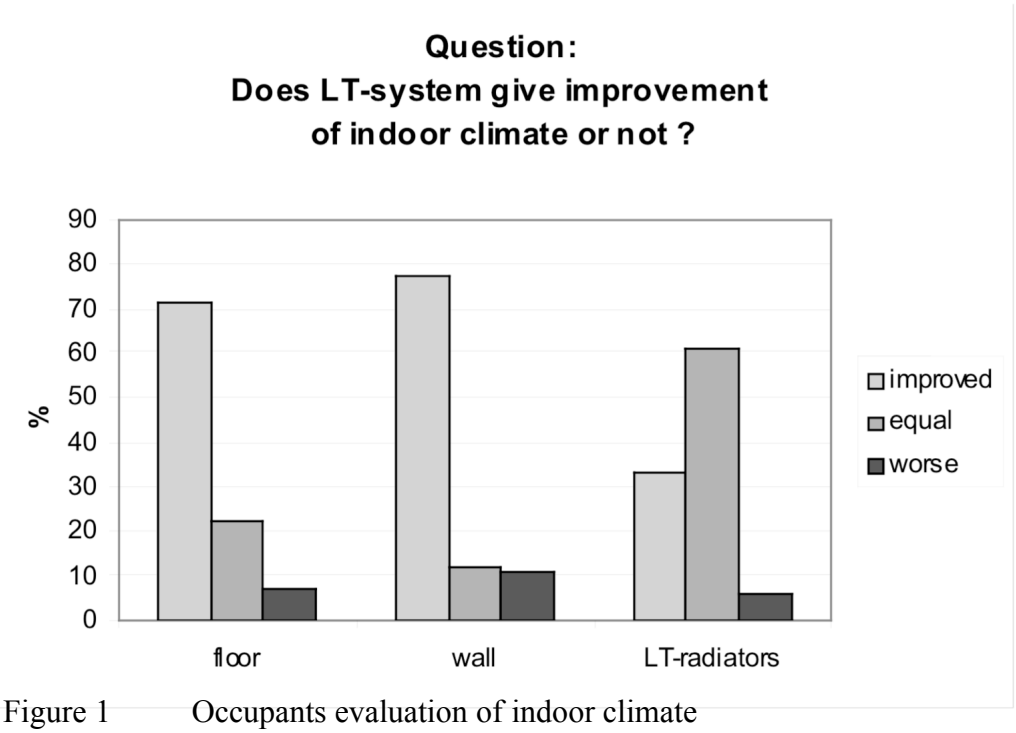

Figure 1 Occupants evaluation of indoor climate

5. STATUS BY THE END OF 2001 / CONCLUSIONS

At the start of the implementation programme in 1997, a market analyses was performed (van Bruchem, 1998) to get a good picture of the attitude of the main target groups (real estate developers, architects, HVAC consultants, suppliers, building contractors, installers, and end users) towards LTS. This market analysis showed that at that time LTS were largely unknown in the Netherlands, except with suppliers, and to a lesser extent HVAC consultants and installers. Due to the efforts of the implementation programme this situation has dramatically changed by the year 2001. From extensive contacts with the market we know that at present low temperature systems are widely known amongst the main target groups.

This and recent monitoring results showing an increasing trend in the yearly number of dwellings being equipped with LTS, raises confidence that the market introduction phase will be able to establish low temperature heating as the standard option for heating in the Netherlands within a few years. Advantages of LTS in terms of thermal comfort, indoor air quality, and safety found in literature, and the results from occupants surveys confirming these advantages, give support to this optimism.

An important element will be the quality of the LT-systems to be realised. If the quality of these heating systems is not adequate, this can cause a devastating setback in the acceptance of LTS. For that reason quality assurance and commissioning of the realisation process of LTS should be of major concern for a successful market introduction. However, if this will be coped with, it's the combination of 'outdoor' environmental benefits and improved quality of indoor environment that will be the key to a successful large-scale introduction of LTS in the Netherlands within a few years.

The central lesson learnt from this programme is, that only concepts (like Low Temperature Systems) that at the same time contribute to the quality of both, the "outdoor", as well as the "indoor" environment, will be viable in the long run, and can be sustainable in the true sense.

6. ACKNOWLEDGEMENTS

The market introduction programme for LTS has been carried out by NOVEM on behalf of the Dutch Ministry of Economic Affairs and the Ministry of Housing, Spatial Planning and the Environment.

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http://www.ltv.novem.nl (in Dutch) or http://www.novem.org

The Suburb -
an Opposition to or a Chance for a Sustainable City

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1. SUBURB - A CULTURAL PHENOMENON

Contemporary suburb and its specific, monotonous spatial form became the symbol of the urbanization process. It also reveals the spirit and character of the whole industrial civilization (Fishman, 1987). The suburb as a residential area on the outskirts of a city with the new domestic life ideal was probably the most radical rethinking between residence and the city.

During the last century the suburb, a powerful cultural ideal, has become a new form of a city. The original concept of the suburb as an unspoiled synthesis of city and countryside has lost its meaning after the massive postwar decentralization of the most vital urban functions transformed the basic urban system.

No longer can a purely residental area define itself in relation to a centralized urban core, for the suburban periphery has become the favored localization for important enterprises and also large mass housing districts. People who live in every type of modern suburbia often feel alienated from environmental values even if the urban form was primarily thought of as one which should improve living conditions giving the inhabitants more free, well illuminated and ventilated space than the 19th century city.

Existing suburbs do not recall the old ideal entirely. The outskirts of the cities, an this city in particular, developed amorphous structure where clearly defined space is nonexistent. There is no city center, there are no boundaries. Rural (agriculturally run-down), urban and suburban elements "compose" a new space value not possible to be measured in city blocks.

2. THE SUBURBS OF LODZ - THE 19TH CENTURY "EDGE CITY" PATTERN

In Poland the outskirts of cities formed a specific chaotic landscape both similiar and different to that characteristic and well-known from American or English suburbs. The case of the city of Lodz, a rather specific example for a european city could be considered in many ways as a model for industrial town development during the last two centuries.

This medieval, rural town, in the state of nearly complete decline, was suddenly elevated in 1821 to the place for new textile manufactures. This decision started the growth of the city which towards the end of the 19th century exploded to nearly 600.000 inhabitants. Suburban developments often were connected with new factories. So the typical lodz suburb had more from the character of the newest "edge city" (Garreau,1992) characteristic than the typical residential area profile of the symbolic english suburb.

Rigid street pattern in the city core, the lack of regular incorporation policy since 1853 and undergoing uncontrolled speculative parcelling in the suburbs, just outside the city's municipal border have lead to other specific land use pattern. The outer districts of the city get more closed and more complicated in space structure as downtown areas. The timber houses extended even to five stories. The greenery deprived streets were relatively narrow and sided with long wooden hoardings. The largest suburb Baluty had grown to 100.000 inhabitants before its incorporation in 1915. In the eyes of the law it was merely an ordinary village, with all the consequences. (Mikielewicz,1999)

The unique timber house landscape of the old lodz suburbs gave way to a new modernistic prefabricated housing after 1945. The area of post-war development covers twice as much as the historical center. Before the second world war mass housing estates had existed in the form of social and cooperative housing as small complexes in outer parts of the city. These two housing estates constituted the avant-garde branch of Polish architecture of the 1918-1939 period. Both estates are composed of three-, or four-storied buildings of stair-well and balcony-acess type, built closed, with elongated courtyards in one case and situated at right angles to the streets in the other.

Because of the small degree of war time devastation the post-war structures transformed, sometimes very radically, the old suburbs and open areas. The mass housing estates rarely stepped beyond the technological routine of their construction. They can be grouped in three stages: social-realistic (the nearest to the traditional street-square city structure), functionalist traditionally constructed and large panel prefabricated (since the 1960s). (Wesolowski, Koter, 1993) The large mass houses estates were built without necessary social and commercial infrastructure. Even if the green areas and public utilities were planned they were mostly only partially realised or not realised at all.

First in the 1980s row houses started to line up suburban streets. Since the late eighties we can notice a stronger tendency to abandon the prefabricated mass housing in favor of row-, or detached houses. It is very peculiar that some layouts of the urban plans for row-housing (also the quality of the inner space of these buildings) copy the structure and feeling of prefabricated mass housing areas.

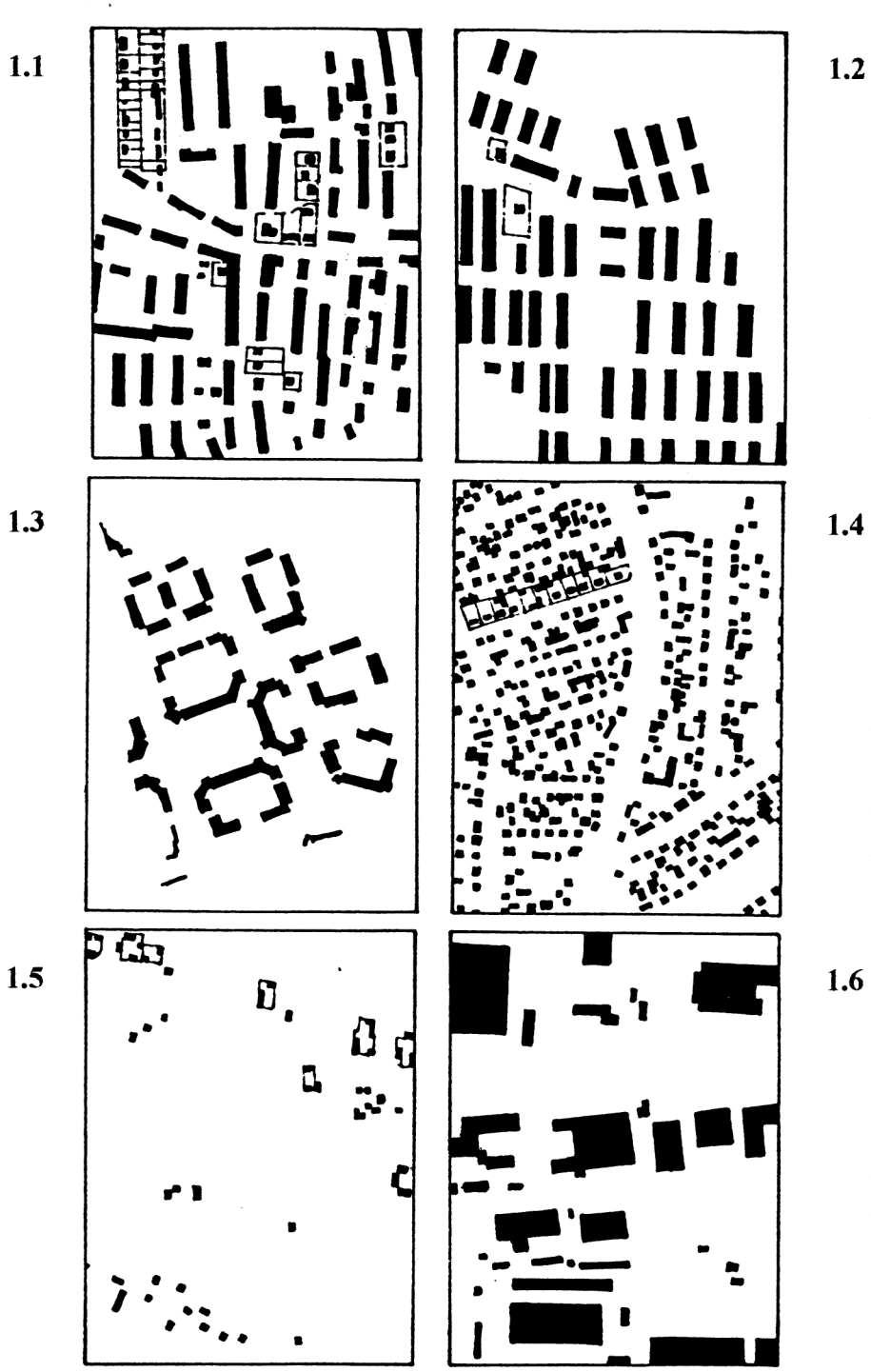
The economical change after 1989 brought with it also another change in the landscape of suburban areas - new developers offices started to build different kinds of guarded and standardized housing estates.

In only a few cases, new housing districts kept the traces and the constrains of the existing urban structure. Single one-family houses on fenced lots remained in the middle of the ten-storied building strustures. These houses were destined for future demolition and their standard and comfort were well behind what we could expect from residental housing. But these "implants" have every chance to be a good starting point in the restructuring process.

3. A METHOD IN ECOLOGY - SUSTAINABILITY IN THE CITIES

An analysis of the suburb's development processes enables, at least partially, to provide with an answer to questions concerning both urbanization threats and methods for solving problems related to the way individuals function in built environment. The quality of urban spaces in suburban areas is contingent on working with the objectives of a greater sense of

identity. An assumption that unity of architecture, landscape and urban design ought to be an



1.1	Mass housing estates, 1957-75	1.2	Row houses estates, after 1980
1.3	Mass housing estate, after 1979	1.4	Detached one-family houses
1.5	Rural areas within city limits	1.6	Industrial, suburban estate

Figure 1. Lodz, Poland. Examples of the space structure of typical suburban land use patterns

obligatory standard in future requires an especially sensitive approach to the present state of this part of the town's space. The focus on these, in Polish reality mostly forgotten, areas of the cities, places which have meaning for those who live in them, is very important. And not only because of the increasing number of people living there, but also because of their importance in the city's ecosystem as whole.

A good design has to be flexible and keep answers prepared for future developments. Transforming processes need a plan and an environmental approach to restructuring methods. And then even if we used in design ecological technologies (as solar collectors, green roofs etc. we do not have a real ecological design. It is also necessary to remember that ecological approach in design makes necessary thr search for very unique, individual solutions for every area that is designed or restructured.

3.1 Reciprocal Bonds - Out- and Inside Connections

The comparison of land use patterns throughout the history of town-planning and the specific characteristic of the development process of the city of Lodz and its suburbs allows us to distinguish a characteristic belt placed near city border, vital to the way of future development of the town-like structure, from the city space. The administative borderline of the city separating areas of different juristiction was always a very important element in the city's development. From this point of view the border area of a city could be defined as a heterogenous area contiguous to the urban areas of the most intensive land use (compact city blocks zone and semi-compact city blocks zone) and the extensive open areas connecting to different degrees, in different periods of time, with the existence of the administrative border of the city.(Mikielewicz,1999)

Reciprocal bonds between the city and its surroundings have various multi-faceted character, but the level of urbanization (suburbanization) is mostly valued for the intensivity of the changes in the landscape, even if land and buildings are relatively fixed features which change more slowly than the social and economic forces around them and land use patterns in extreme cases can lay several decades behind land use processes. The analysis of such elements as f.ex. the size of a city block, a street's density and surface etc. enables us to distinguish subzones within the border zone of the city such as:
- town-like detached development zone
- concentrated detached development zone

and dispersed development zone, each of them establishing their specific characteristic.The differences in the character of the natural environment in every subzone could be described through diverse levels of antropopressure tied up with specific land patterns. The subzones could vary in width in different periods of time. Their existence depends on the individual characteristic of every town, which in turn depends upon the town's genesis, development processes, placement in relation to the main natural system sources etc. Their importance in the ecosystem of the city consists in influence and irreversible change of the development of specific climatic conditions, alteration of soil and water habitat and mostly in the possibility of creation multifunctional corridors joining the city core with open areas. The way in which these areas are built determine the conditions of comfort for the entire city.

3.2 Diversity and Uniqness in Recurrence

The necessity to define processes occuring on the outskirts of a city is urging and nothing but simple. Resulting from continuous interplay between different forces and regulations, urban settlements patterns took amorphous and nondifferential forms of the urban fringe. In effect, this process leads to alienation and disregard for the environment. In a decentralized

environment first to flourish are indeed those structures which rest on standardization. But with the use of high technology this standardization eventually gives way to diversity. The attempt to re-integrate urban man and the natural environment challenges established values and methods. What we need is a dynamic, thorough analysis embracing both constant change and also the strange stability of such areas. An analysis which ultimately leads to a re-definition of the periphery, especially in the context of its sustainability.

4. THE SUBURB - AN OPPOSITION TO OR A CHANCE FOR A SUSTAINABLE CITY

"It was a small private estate of architect-designed houses, built in the traditional manner and set each in a spacious garden. It had little contact with the neighbouring village (...) and was, indeed, an oasis of prosperous suburbia whose inhabitants, bound by ties of common prejudices and snoberies, lived like exiles determinedly preserving the deciencies of civilization in the midst of an alien culture."

P.D.James (1963) wrote an essential description of what is conventionally understood as a suburb. Suburban space of residential and mass housing areas developed a form of depressing anonimity, the effect of cultural and technological standardization. Even if thought of as a refuge from the perils of a city, which meant the necessary connection to the Nature, one might conclude that the real qualification for the builders and designers of old and contemporary suburbs are a total disregard for nature and an overwhelming sympathy for the profit motive.

To ask the paper's title question about the future of suburbia as a model space for a sustainable city is an effort to formulate an answer to the problem of how to use the understanding of the natural process that contributed to the physical form of land development and which in turn was altered by the urban form of the built-up environment and how to reconcile even basic needs of energy, environment and natural resource conservation with the "traditional" thinking about urban design. As architects and urban planners we have to learn to understand that aestetic priorities are secondary to the insights of ecological determinism (Hough,1993). Ecology as the foundation for a philosophy of designing and redesigning suburban areas seems the only way to real improvement in the long term.

What seems to be a new quality in the designing and re-designing of suburban areas and whole cities is really this overwhelming need for a balance between urban and open space. And just as the old suburbia kept alive the ideal of a balance between man and nature in society we should take it as a kind of legacy. This historical and present perspective is necessary to adopt the appropiate, user-responsive, ecology sensitive approach for obtaining a livable sustainable city well into the 21st century.

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Energy efficient office buildings

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SUMMARY
The primary energy consumption of a new office building can be lowered by 70 % just by using the energy saving measures available at the market today. This is the result of a theoretical investigation carried out at the Institut Wohnen und Umwelt (IWU) at Darmstadt, Germany. But not only the environment benefits of an energy "efficient office building". An economic assessment shows that high efficient standard is even profitable. So the "efficient office building" meets both ends: the requirements of the environment an the economic interests of the investors.

TARGET AND PROCEDURE
The possibility to reduce the heating demand of dwellings by more than 80 % was shown in the year 1991 with the construction of the first passive house in Central Europe [Feist 1996], [Feist, Werner 1994]. Up to now more than 1000 passive houses were realised with success.

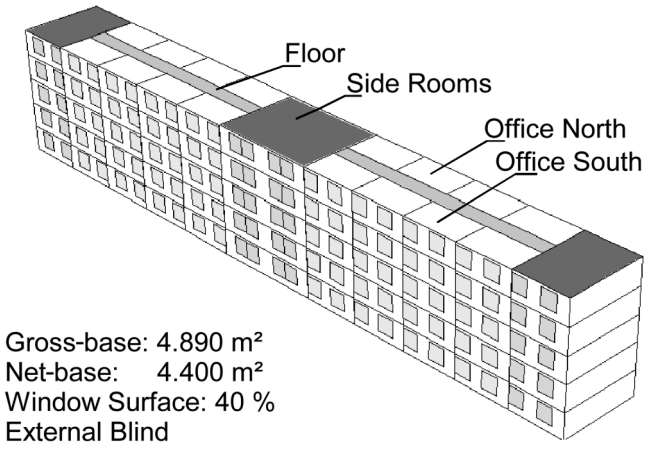

Figure 1: Outline of the examined building

In the investigation introduced here [Knissel 1999] the question was examined, whether such an efficiency increase can be realised in office and administrative buildings as well. So the energy consumption of an example building (Figure 1) was calculated for five different energetic standards. Two of the five variants are shown in the following.

1. Standard office building: The insulation corresponds to the minimum requirements of the thermal protection ordinance (Wärmeschutzverordnung) 1995. Measures to the efficient current use aren't taken up.
2. Efficient office building: It shows the best efficiency standards available at the market today.

The "efficient office building" differs from the "standard office building" in the following points:

- Very high insulation standard of the building cover
- Very low electricity consumption of the equipment and lighting
- No active cooling, humidification and dissecation
- Heat and humidity recovery and an earth tube exchanger.

The energy consumption of the variants are calculated by dynamic building simulations with the program "TAS". For the simulations the weather data of the test reference year No. 6 (Frankfurt am Main) are used as climate condition.

	Gas	electricity (mix)
Primary energy factor kWh_{Prim}/kWh_{End}	1,07	2,97

Table 1: Primary energy factors by [Gemis 3.01]

For the energetic assessment of the building both, fuel and electricity consumption, must be taken into account. This can be done by calculating the primary energy consumption. Therefore the gas and electricity consumption is multiplied with primary energy factors (Table 1). These factors were calculated by using the program Gemis (3.01).

The primary energy index is calculated by dividing the primary energy consumption by the gross base of the building. The energy index of a building consists of various single positions. To reflect the consumption structure, the single positions are divided according to the recommendations of the Swiss engineer and architects organization SIA 380/4.

PRIMARY ENERGY SAVING

For the two variants the annual primary energy requirement is calculated by using dynamic thermal simulations. The whole primary energy value of the building as well as the division on the different positions is shown in Figure 2.

By the increase of the energetic efficiency the primary energy requirement of the examined example building can be lowered from 235 kWh/(m² a) to 67 kWh/(m² a). This corresponds to a reduction of about 70 %. In the following it is briefly outlined how the savings are reached. The text concentrates on the important positions. A detailed description is found in [Knissel 1999].

Heating

The primary energy consumption for heating of the efficient office building is only 18 kWh/(m² a). Such a low value is reached by

- Insulation thickness between 30 cm to 40 cm
- Triple thermal protection glazing together with high-insulated window frames
- a ventilation plant with efficient heat recovery and an earth tube heat exchanger.

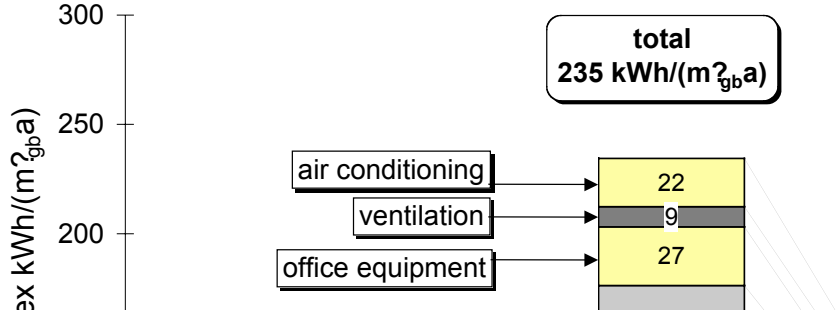

Figure 2: Primary energy index for the “standard” and the “efficient office building”

The positions “hot water”, “various technics” and “ventilation” are not discussed

Lighting

About 50 % of the total primary energy savings appear at position “lighting”. This is realised by

- high-efficient fluorescent lamps
- A lighting control, which switched off when exceeding the norm lighting intensity.
- dividing the room in zones with different lighting intensity [Hofmann 1998]. A base illumination of 220 Lux is reached by the ceiling-lamps. At the workspace 500 Lux are gained by a desk lamp.

Office equipment

By the use of the efficient equipment the primary energy consumption can be lowered from 27 kWh/(m $^2_{gb}$ a) to 4 kWh/(m $^2_{gb}$ a). In the “efficient office building” the following equipment is used:

- Notebooks as computer
- Photocopier, printer and fax with an electricity consumption of 75 % of the GED limiting values of 1998. [GED 1998]. Explanation: The community energy label Germany "GED" marks out a list of office products every year, which fulfil certain efficiency standards.

Air conditioning system

A primary energy consumption of 23 kWh/(m$^2_{gb}$ a) is required in the “standard office building” for humidification and dissecation as well as for the active cooling. In the “efficient office building” these functions can be renounced since the space comfort stays in the desired area itself. Also there is no air-conditioning system the primary energy index isn't zero since the consumption for night ventilation and free cooling is credited under this position.

The discussion points out, that no technical problems exist realising high “efficient office buildings”. All the energy-saving measures are available at the market today.
Another important question is to look at the additional costs for this high efficiency and the economy.

ECONOMIC ASSESSMENT

To assess the economy of the “efficient office building”, all payments which arise within a period of 30 years are looked at: the additional investment costs, the replacing investment after expiring the respective life time and the annual saving of energy and maintenance costs. The signs of the payments are defined as follows:

- savings: positive value,
- additional costs: negative value.

The value added tax isn't included in the payments. The assumed additional costs and savings are shown in Table 2.

Table 2: Additional costs and savings for the energy efficient office building

Additional costs and savings			Annual savings	
	€	life time		€/a
Insulation	-385.000	30	Electricity costs	26.000
Lighting	55.000	15	Gas costs	5.000
Office equipment	-160.000	5	Maintenance costs	8.000
HVAC* system	269.000	15		
Sum	**-221.000**		**Sum**	**39.000**

* Heating, Ventilation and Air Conditioning

From the discounted single payments the capital value of the investment is calculated. If the capital value is positive, the investment is profitable, if it's negative the investment is unprofitable. The boundary conditions of the economy calculation can be taken from Table 3.

Table 3: Boundary conditions of the economic assessment

Time period	30 years
Price of electricity	0,13 €/kWh
Gas price	0,022 €/kWh
Maintenance costs	2,5 % p.a. of the investment costs
Rate of inflation	2 % p.a.
Increase of energy price	2 % p.a. (nominal)
Increase of the maintenance costs	2 % p.a. (nominal)
interest rate	6 % p.a. (nominal)

Figure 3 shows the results of the economical assessment. It points out the payments calculated under these conditions for a time period of 30 years as well as the capital value of the total investment. An owner–occupied building is looked into. The owner-occupier must pay the investment costs, however the energy and maintenance cost savings also are of benefit to him. So all payments can be added to calculate the capital value.

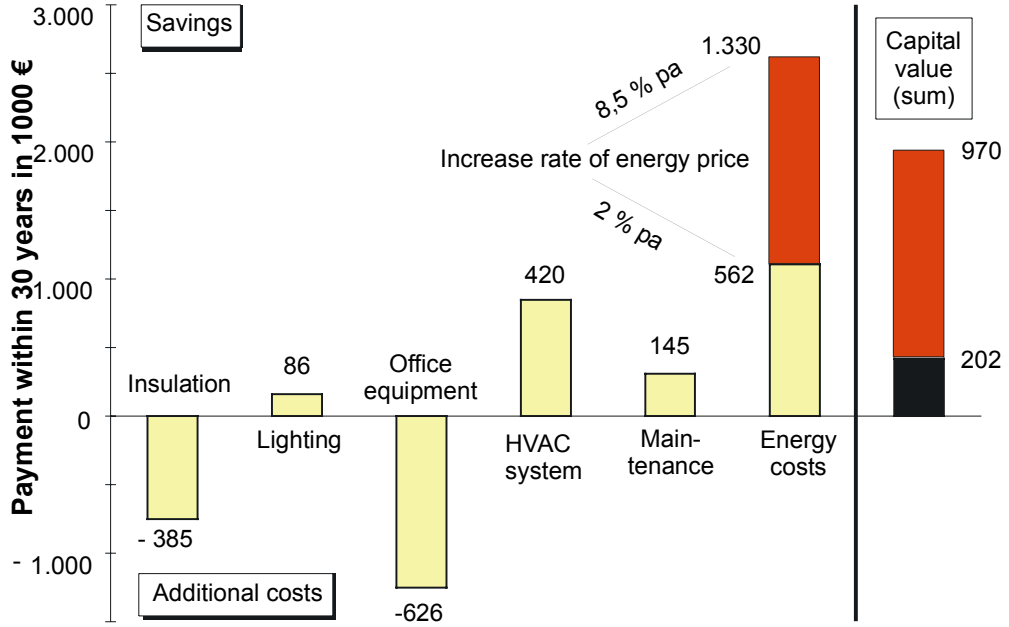

Figure 3: Additional costs and savings within 30 years for the "efficient office building"

Over the time period of 30 years the expenditures of an owner-occupier decrease. Thus it is economical for him to realise the "efficient office building" At a low energy price increase of

2 % p.a. the savings amount to 210.000 €. If the price of energy rises strongly around 8.5 % p.a., savings of 1.000.000 € show up. If the building is rented out, the same increase or decrease expenditure exists. They must however be settled by different parties or be of benefit to them.

The economical assessment points out that it is the right choice to build the office building in an high efficient standard, not only from ecological but also from economic points of view.

CONCLUSION.

Transforming these results to other projects you must consider that the primary energy savings and the capital value depend on the actual boundary conditions. Because of this the energy savings and economy must be determined individually. Nevertheless it gets clear that a high efficient standard has positive effects. It reduces the primary energy consumption and can lead to savings for the investors. The additional costs for the insulation and the efficient office equipment can be compensated by the low energy and maintenance costs and the decreasing investment costs for the lighting and the HVAC system. Because of this the high efficient option “efficient office building” should be checked for every new building.

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Assessing the building sector's most important materials from an energy and material resources perspective

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1. INTRODUCTION

The environmental discourse in society, including the building sector, alters its focus depending on societal change. The issue of what is most important is, of course, contingent upon values and no research methods could point out the one and only issue that should have the highest priority. Still, societal actors have to decide what to concentrate their efforts on. According to the Swedish government (1993), one general and significant environmental issue is how to improve the economy of material and energy resources (see also Bringezu and Schütz, 2001). In this area there are several examples of activities that deal with reuse of materials, components and products. Both societal and academic actors advocate reuse measures to close the material cycles, in order to improve the economy of material and energy resources (c.f. Swedish Government, 1993; Erkman, 1997). One of the building sector's responses to this has been selective demolition, which is used, for instance, when dwellings are demolished in order to facilitate reuse. However, since reuse processes also contribute to environmental impact and require energy and materials, the reuse measures should be environmentally evaluated to find which building materials are the most important to reuse and how they should be reused.

Reuse of materials and products could be accomplished using different measures and techniques. Connelly and Koshland (1997) propose that the general term reuse should be divided into three categories (here presented in order of decreasing material quality). First of all, 'recirculation,' which conserves the internal material quality and means direct reuse, where no or minor energy is required to process the material. The second category, 'upgrading,' is separated into 'recycling' and 'partial recycling.' This form of reuse includes the adding of energy to bring the material back to its preconsumed (i.e., high material quality) state (ibid.). 'Partial recycling' refers to the case when this is done only to some extent; not aiming for the initial high material quality. Finally, there is the case of 'cascading,' which means that the material quality is degraded (ibid.). One example of cascading is when a concrete frame structure is crushed and the material is reused as aggregates in a road structure. Since the original application of materials may still require virgin raw material supply, reuse by partial recycling and cascading may not conserve natural resources (Connelly and Koshland, 1997). Furthermore, as reuse processes also could be energy intensive, it is important from a life-cycle perspective to environmentally evaluate reuse alternatives compared to what is substituted, i.e. mainly virgin natural resources.

Because of the ongoing structural changes of depopulation in Sweden, the buildings demolished today mainly are dwellings from the 1960s to 1980s, located in smaller industrial towns. Since multi-family dwellings mostly have technical lifetimes longer than 20 to 40 years, these buildings are demolished before the end of their designed service life. Consequently, the energy embodied in these building materials and products makes these more energy intensive in a life-cycle perspective.

Our research generally aims to find out which reuse strategies are environmentally beneficial for materials in the building sector. This will be done by use of a life-cycle approach, where different reuse measures for building materials or products can be compared. As an indicator of environmental impact, energy use will be chosen. Hereby we assume that the parameter 'energy use' generally reflects the environmental impact. This assumption will only be slightly touched upon in this paper, which is the initial part of the research project, and more closely discussed in forthcoming research articles. In order to contribute to the improvement of the economy of material and energy resources, this paper will discuss an approach to determining the building materials of main interest from a material and energy resources perspective. This approach is based on the concepts of the material stock, embodied energy and service life. The aim of this paper is then to point out the most significant building materials that should be focused on in environmental-related building research and also in environmental management in the building sector.

2. ENERGY AND MATERIAL RESOURCES ASPECTS

The material flow perspective, also termed industrial metabolism, addresses the material and energy flows in the industrial society. The expression "industrial metabolism" is a metaphor describing the resemblance of the use of materials and energy in society to the natural bio-geo-chemical cycles of substances and materials (Ayres, 1994). The industrial material cycles, or industrial metabolism, could be described by the metabolism of materials and energy in industrial processes: through linear "cycles" of high-quality resources, such as refined metals, degradation in internal material quality through industrial processes that produce complex consumer products, and by the use of the final product. Lastly, the product ends as waste. All of these processes require energy (c.f. Schmidt-Bleek, 1993; Ayres, 1994). During the product life cycle, there are losses of the original resource into the environment, either from point sources or as dissipative losses, i.e. a loss in such a way that the material is impossible to recover. Since the sources of energy in society still mainly are non-renewable, these contribute to the net input of carbon dioxide into the atmosphere. This fact favors the idea of using energy as an indicator for environmental impact.

2.1 The material stock

Having large quantities of materials with long lifetimes, such as building materials and building products, stocked in society means that the materials will remain in society for a long time after they are no longer produced (Baccini and Brunner, 1991). This means that minor environmental impact of a single product could extend to significant environmental issues and could consequently be inconvenient if the stock leaks environmentally harmful substances (compare, for instance, with PCB, which still has observable effects despite being banned in western industrialized countries in the 1970s). However, a large stock of materials with a long service life, such as concrete, steel and brick, may also be seen as reservoirs of materials that could be reused in the future (Lahner and Brunner, 1994). Knowledge about the composition of the building stock is therefore, as discussed by Thuvander (2000) and Kloft and Wörner

(1999), important in order to plan for present and future management of the building stock and also in order to facilitate a decreased environmental impact.

2.2 Energy use in a life-cycle perspective

The concept 'embodied energy' is one attempt to describe the use of energy to produce a material or product from extraction of raw materials, through transporting, processing, and production of a usable product (c.f. Cole and Rousseau, 1992; Friedman and Cammalleri, 1995; Alcorn, 1998). Sometimes, this is referred to as a "cradle-to-gate" perspective. In contrast to life-cycle assessments (LCA) (c.f. ISO 14031:2000), embodied energy does not take into account the occupation, maintenance or end-of-life phases. However, if the material were to be used as fuel, its calorific value, i.e., the thermal energy potential of the feedstock, would be considered. Nevertheless, since this study derived from an interest in the current building material stock, it was suitable to apply the embodied energy concept in order to estimate the total amount of energy embodied in the building stock.

In most cases, applying the LCA method includes analysis of numerous parameters reflecting the study object's environmental impact and environmental performance. Using the concept of embodied energy limits the vast amount of parameters to only one. However, this procedure still outlines central aspects of the environmental impact and environmental performance of a material, product or process. Since the main sources of energy still are fossil based, especially for energy-intensive production processes, the total amount of energy used will also reflect emissions of carbon dioxide. Furthermore, all kinds of combustion processes also lead to emissions of nitrogen oxides, which, however, can be reduced through internal process measures and end-of-pipe measures. Additionally, emissions to air such as particles and polyaromatic hydrocarbons (PAH) are also associated with energy conversion. However, by applying the concept of embodied energy, neither emissions to water and soil nor toxicological and health aspects are entirely or transparently reflected.

2.3 Service life

Concerning those cases where the dwellings are demolished due to depopulation, the building's service life has come to an end. However, the building components could very well be fit and have remaining service life. In order to facilitate resource-efficient use of materials and energy, it would be important to consider environmental aspects in service life planning of buildings and building components. As stated in the international standard about service life planning (ISO 15686-1:2000) "future repairs, removal, reuse, dismantling and disposal should be considered in the design stage" which would facilitate reusing building components as construction materials in new building construction (c.f. Roth and Eklund, 2000).

Since structural building materials and products have long-term service life, the environmental impact from processes such as extraction, refining, manufacturing and disposal would be dispersed over many years. Considering use of energy, life-cycle studies of buildings usually point to occupation as the most significant phase. For instance, Adalberth (1999) states that energy in occupation of a multi-family dwelling in Sweden represents approximately 85% of the energy required in the entire life cycle. However, if the building's service life ends before the predicted service life, life-cycle phases such as extraction of raw materials, manufacturing of products, construction, transport and end-of-life measures increase in importance.

The Swedish Board of Housing, Building and Planning (Boverket) recommend a service life of minimum 100 years for structural elements that are not accessible for inspection and

maintenance and minimum 50 years otherwise (Swedish Board of Housing Building and Planning, 1998). Additionally, the international standard (ISO 15686-1:2000) proposes design lives for five categories of building components. These categories are: i) the entire building, ii) inaccessible or structural components, iii) components where replacement is expensive or difficult (including drainage underground), iv) major replaceable components and v) building services. The design lives proposed depend on the design life for the entire building: minimum 150, 100, 60, 25, 15 or 10 years. The longer the building components are in use (i.e. the longer service life), the more efficient the energy use required to produce the component. It is, however, not obvious how long the service life of a specific building component could be; it depends very much upon the environment and the conditions in which it is used (ISO 15686-1:2000).

Various reuse measures would affect the service life for building components differently. Firstly, recirculation means that the entire service life of a building component could be utilized. Secondly, upgrading would mean to recondition a building component because energy would be added and thereby the service life of the component extended. Finally, cascading of building components implies degradation of the internal material quality, which means that the material would only be reused in products where the material quality requirements are lower. This procedure would extend the service life for the building material, but not for the building component, which would no longer exist. It is often argued that virgin natural resources are substituted through cascading. However, if there still were demands for the original product this would nevertheless require raw materials in the production process and the degraded building component might only substitute for some material in the new application.

3. AN APPROACH TO DETERMINING THE BUILDING MATERIALS OF MAIN INTEREST

Concerning energy and material resources, an approach to assessing the building sector's most important materials could be based on the quantity of materials in the building stock (Q), embodied energy in the materials (EE) and estimated service life (SL). This results in a measure, here termed I. The idea was to rank the materials according to their occurrence in society with respect to the energy invested. However, since building materials have diverse service lives, the product of the material quantity in the stock and its embodied energy was divided by the time the material could be estimated to be in use (Eq. 1). The very simple mathematical operation used here to place the building materials in order of rank is:

$$Q_i * EE_i / SL_i = I_i \quad (1)$$

where i represents each material or product category in the Swedish building stock. This would give an indication of the amount of energy invested in the stock of diverse materials and therefore point out which are the most significant to study.

The main problems using this approach were to find representative and transparent data of appropriate quality. However, to carry through this selection process, we used several different data sources. This means that diverse system boundaries may have been used to calculate embodied energy in the different studies and that the national energy systems where the building products are used and produced sometimes were non-Swedish. Therefore, the calculated embodied energy may differ from the Swedish case. Another difficulty was that, because proper data were not always available, assumptions had to be made.

3.1 The main materials stocked in the Swedish building sector

In 1996 the Swedish Environmental Protection Agency initiated a national inventory describing the main material groups in the Swedish building and construction sector (see AB Jacobson & Widmark (1996)). This national inventory was an attempt to actually find out which materials were stocked in buildings and which quantities were annually built in through new building projects, repairs and extensions. The lack of this knowledge was considered to obstruct the building sector's movements towards environmental improvement (AB Jacobson & Widmark, 1996). This national inventory was used as a starting point in order to distinguish the materials of main interest from a material and energy resources perspective (c.f. results section, Table 1, column 'Stock'). It can be assumed that some of the material categories in Table 1 contain more than one product. The figures in the national inventory excluded maintenance; waste material due to maintenance, new constructions, renovations and extensions; structures belonging to the Swedish army; pipes for water and sewage; electrical wires; telephone circuits outdoors and underground; pipes for heating and drinking water underground; haydite (a form of concrete consisting of expanded and burnt clay, and some sand); finish; putty compound; adhesives; non-fixed wardrobes, white goods, furniture, joineries, textiles except fixed carpets; scaffolds; formwork timber; and poles (AB Jacobson & Widmark, 1996).

3.2 Inventory of embodied energy

For a number of the material categories we found several data sources presenting figures on embodied energy (c.f. results section, Table 1, column 'Embodied energy'). Primarily, since the starting point was the national building stock, we chose to use Swedish data and the latest publications. All of the data sources used explicitly stated that when applicable, the calorific value was taken into account. The calorific value is also estimated for wood and plastic materials, roofing felt and linoleum.

Data on embodied energy were not always available or feasible and therefore some assumptions had to be made (see the material categories 'alloyed steel,' 'paving stone' and 'steel, cast iron' in Table 1).

3.3 Service life

As an example we chose to illustrate the importance of service life with a building designed for 60 years (c.f. ISO 15686-1:2000; Swedish Board of Housing Building and Planning, 1998). This means that the design life of inaccessible or structural building components and components where replacement is expensive or difficult also was set to 60 years (ISO 15686-1:2000; Swedish Board of Housing Building and Planning, 1998). Furthermore, the design life of major replaceable components was set to 40 years and for building services it was 25. Because some of the material categories in this study could contain several building products, the assumed service life differs from the proposal in the ISO standard 15686 (c.f. results section, Table 1, column 'Service life'). The uncertainty in this procedure implies that it should be seen as an attempt to illustrate the dependency of service life.

4. RESULTS

The largest quantity of embodied energy with respect to the years a building material is in use was found for the individual category untreated wood, then, in decreasing order, alloyed steel, common bricks, wood (surface treatment), ready-mixed and prefabricated concrete, aluminum, paint, fibreboard, lightweight concrete, gypsum plaster boards, and polyvinyl chloride (Table 1).

Table 1 The Swedish national building material inventory is presented in the column Stock (Q in Eq. 1). The following columns show the embodied energy (EE in Eq. 1) and the calorific value, for each material. Further, a calculation of the embodied energy in the Swedish building stock is presented. Thereafter, the assumed service life (SL in Eq. 1). The last column shows the embodied energy with respect to the years a material is in use (I in Eq. 1), the calorific value in parenthesis. The materials are arranged by their magnitude in the building stock.

Materials	**Stock[1], [ktonnes]**	**Embodied energy, [MJ/kg]**	**Calorific value, [MJ/kg]**	**Embodied energy in stock, [MJ]**	**Service life, [yr]**	**Embodied energy with respect to the years in use (calorific value in parenthesis), [MJ/yr]**
Concrete, ready-mixed	3.9E+05	5.9E-01[2]		2.3E+11	60	3.8E+09
Sand/gravel/ coarse gravel	2.0E+05	5.0E-03[3]		1.0E+09	60	1.7E+07
Common bricks	1.4E+05	3.1E+00[4]		4.4E+11	60	7.4E+09
Concrete, prefabricated	1.3E+05	1.6E+00[5]		2.1E+11	60	3.6E+09
Natural stones	7.0E+04	1.0E-01[6]		7.0E+09	60	1.2E+08
Macadam	5.7E+04	6.8E-02[3]		3.9E+09	60	6.4E+07
Untreated wood	4.9E+04	2.1E+01[7]	1.6E+01[8]	1.0E+12	60	1.7E+10 (1.3E+10)
Lightweight concrete	2.9E+04	3.5E+00[9]		1.0E+11	60	1.7E+09
Shaping materials	1.6E+04	?				
Alloyed steel	1.6E+04	2.3E+01[10]		3.6E+11	40	9.0E+09
Wood, surface treatment	1.1E+04	2.1E+01[3]	1.6E+01[8]	2.4E+11	40	6.1E+09 (4.6E+09)
Gypsum plaster boards	9.6E+03	6.0E+00[11]		5.8E+10	40	1.4E+09

[1] AB Jacobson & Widmark (1996).
[2] Thormark (2001). Friedman and Cammalleri (1995) and Alcorn (1998) give figures of the same order.
[3] Thormark (2001).
[4] Thormark (2001). Alcorn (1998) gives figures of the same order, Adalberth (1999) lower.
[5] Thormark (2001). Alcorn (1998) give figures of the same order.
[6] Berge (1995).
[7] Thormark (2001). Friedman and Cammalleri (1995) give figures of the same order, Adalberth (1999) lower.
[8] Thormark (2001). The Swedish Environmental Protection Agency (1996) gives figures of the same order, Adalberth (1999) lower.
[9] Thormark (2001). Adalberth (1999) gives lower figures.
[10] Includes stainless steel. Thormark (2001). Friedman and Cammalleri (1995) and Alcorn (1998) give figures of the same order, Adalberth (1999) lower.
[11] Thormark (2001). Friedman and Cammalleri (1995), Alcorn (1998) and Adalberth (1999) give figures of the same order.

Materials	Stock[1], [ktonnes]	Embodied energy, [MJ/kg]	Calorific value, [MJ/kg]	Embodied energy in stock, [MJ]	Service life, [yr]	Embodied energy with respect to the years in use (calorific value in parenthesis), [MJ/yr]
Roofing tiles, clay	7.7E+03	3.3E+00[9]		2.5E+10	40	6.4E+08
Paving stones	5.0E+03	7.9E-01[12]		4.0E+09	60	6.6E+07
Other bricks /ceramics	4.9E+03	3.3E+00[9]		1.6E+10	40	4.0E+08
Stone wool	4.0E+03	1.4E+01[9]		5.6E+10	60	9.3E+08
Steel, cast iron	2.6E+03	1.3E+00[13]		3.4E+09	40	8.5E+07
Particle board	2.3E+03	7.9E+00[14]	1.5E+00[15]	1.8E+10	25	7.3E+08 (1.4E+08)
Glass	2.2E+03	1.8E+01[9]		4.0E+10	40	9.9E+08
Wood-wool building slab	2.1E+03	9.2E+00[3]	6.3E+00[8]	1.9E+10	25	7.7E+08 (5.3E+08)
Fibreboard	1.8E+03	2.5E+01[5]	1.8E+01[8]	4.5E+10	25	1.8E+09 (1.3E+09
Asbestos cement	1.8E+03	?				
Glass wool	1.6E+03	2.9E+01[4]		4.6E+10	60	7.7E+08
Polyvinyl chloride	7.5E+02	7.2E+01[4]	1.9E+01[16]	5.4E+10	40	1.4E+09 (3.6E+08)
Paint	7.4E+02	3.0E+01[9]		2.2E+10	10	2.2E+09
Wood, impregnated	7.0E+02	2.1E+01[3]	1.6E+01[8]	1.5E+10	25	6.0E+08 (4.5E+08)
Aluminum	6.3E+02	1.8E+02[4]		1.1E+11	40	2.8E+09
Roofing felt	5.2E+02	2.2E+01[9]	1.8E+01[3]	1.2E+10	25	4.6E+08 (3.8E+08)
Plywood	4.0E+02	2.8E+01[4]	1.7E+01[8]	1.1E+10	25	4.4E+08 (2.7E+08)
Copper	3.0E+02	7.2E+01[4]		2.2E+10	40	5.4E+08
Linoleum	2.5E+02	3.4E+01[3]	1.8E+01[3]	8.5E+09	20	4.2E+08 (2.2E+08)
Polyethylene	2.3E+02	9.1E+01[4]	4.6E+01[16]	2.1E+10	25	8.4E+08 (4.2E+08)
Other plastics	1.5E+02	7.9E+01[3]	4.0E+01[17]	1.2E+10	25	4.7E+08 (2.4E+08)
Polystyrene	1.3E+02	1.2E+02[4]	4.2E+01[16]	1.6E+10	25	6.2E+08 (2.2E+08)
Jointing materials	1.2E+02	?				
Paving bricks	7.0E+01	3.3E+00[3]		2.3E+08	40	5.8E+06
Zinc	3.5E+01	4.6E+01[4]		1.6E+09	40	4.0E+07

In order to facilitate the interpretation of this list, the materials were categorized into fewer, larger material categories (Table 2).

[12] Approximately the same as "stone, dimension, local" (c.f. Alcorn, 1998).
[13] Approximately the same as reinforcement bars (c.f. Adalberth, 1999).
[14] Björklund and Tillman (1997) and also Alcorn (1998).
[15] Adalberth (1999).
[16] Svenska renhållningsverksföreningen (1996). Thormark (2001) gives higher figures, Adalberth (1999) lower.
[17] The Swedish Environmental Protection Agency (1996).

Table 2 The material categories in Table 1 are summarized into expanded material categories: i) *wood materials* containing untreated wood, wood (surface treatment), particle board, wood-wool building slab, fibreboard, wood (impregnated) and plywood, ii) steel, i.e. alloyed steel and cast iron, iii) bricks and other ceramics containing common bricks, roofing tiles of clay, paving bricks and other bricks and ceramics, iv) concrete, both ready-mixed and prefabricated, v) other metals, meaning aluminum, copper and zinc, vi) plastic materials containing polyvinyl chloride, polyethylene, polystyrene and other plastics, vii) paint, viii) mineral wool, which is stone wool and glass wool, ix) lightweight concrete, x) gypsum plaster boards, xi) glass, xii) roofing felt, xiii) linoleum and xiv) macadam, stone and gravel. The materials are arranged by their magnitude of embodied energy in the stock and normalized for the predicted years in use, the calorific value in parenthesis. In each category the share of the dominant materials is shown.

Materials (the share of the largest materials or products based on I in Eq. 1)	**Embodied energy with respect to the years in use (calorific value), [MJ/yr]**
Wood materials (60% untreated wood)	2.8E+10 (2.0E+10)
Steel (99% alloyed steel)	9.0E+09
Bricks and other ceramics (almost 90% common bricks)	8.4E+09
Concrete (50% ready-mixed and 50% prefabricated)	7.4E+09
Other metals (80% aluminum)	3.4E+09
Plastic materials (40% PVC, 25% PE, 20% PS)	3.3E+09 (1.2E+09)
Paint	2.2E+09
Mineral wool (50% stone wool and 50% glass wool)	1.7E+09
Lightweight concrete	1.7E+09
Gypsum plaster boards	1.4E+09
Glass	9.9E+08
Roofing felt	4.6E+08 (3.8E+08)
Linoleum	4.2E+08 (2.2E+08)
Stones and gravel	2.6E+08

5. DISCUSSION AND CONCLUSIONS

It should be noted that the results from this study (Table 1 and Table 2) only picture the current stock (or at least in 1996) and even though the changes are slow the present situation may differ from the one pictured in this paper. This study does not indicate anything about the current inflows or outflows of materials, i.e., what is built into the current and future building stock and what is taken out through repairs and demolishing. However, this approach to rank the building materials with concern to energy and material resources indicate the environmentally most important materials.

The building materials of main interest from an energy and material resources perspective and considering the time these are in use, were wood materials and steel, according to Table 2. If solely the quantities of building materials in the stock (Table 1) were considered, this would

change the priority to inert materials such as concrete, bricks, gravel and stones. However, the most energy-intensive materials in terms of embodied energy are plastic materials and metals such as aluminum, copper and zinc. Also considering the time period a material could be in use, the total material quantities and the amount of energy embodied in a building product are in a way normalized and the building materials could to some extent be compared. It should be noted that the four largest material categories (Table 2) contain mainly structural materials having long service lives.

One implication of the results is that large energy investments in building materials distinguish which materials are significant from a material and energy resources perspective. These energy-intensive materials are the ones to primarily consider in material and energy resource management programs and environmental-related building research. Reducing these materials' energy intensity may not easily be an issue of the building sector, but to improve the resource economy of these material categories may be possible, for instance, through the development of systems for material recirculation and through design considerations.

The energy invested in the materials from cradle to building product is largely impossible to recover, except when there is a calorific energy value, which at least could be utilized in, for instance, combustion plants with heat recovery. Considering that most of the building materials used, with respect to the quantity in the building stock, are inert materials and also non-renewable, it is important to utilize the product for as long as possible in the first place and reuse the material in the second place, i.e., considering measures such as recirculation and upgrading. However, concerning the embodied energy stocked in the building sector, a non-ignorable part has a calorific value. A minor fraction of that part consists of non-renewable materials, e.g., plastic materials and roofing felt that rather should be recirculated or upgraded.

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Forward to the Past

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1. INTRODUCTION

On the basis of both empirical experience and quantified research studies - we have found that the more sustainability principles are applied to the design and planning of Northern European towns and cities - the more these tend to take on traditional forms. Historically, these evolved through a combination of economic, cultural and environmental criteria operating over time. In general, the Northern European model is of shelter from predominant wind and rain. The Mediterranean model is of sheltering from the sun. This results in differences not just in scale and proportion (narrowness of streets, etc) but also in the selection and use of both building and landscaping materials. Local benefit is also derived through use of local labour and materials which lead also towards a more localised aesthetic - whereas an international style generates needs for importing both materials and skills. The predominant modern architectural type of the single building in place of more traditional "joined up" forms has adverse environmental effects.

2. URBAN FORMS

The basic building blocks of traditional European towns lie in the street, the block and the square. The types of town can be characterised as:

Planned: Designed to a regular pattern, often with one particular function to the fore (military, transport, etc) There is a repetition of forms and dimensions.

Organic: Not designed by any one hand, the organic town is nevertheless often governed by rules. Often these are not aesthetically based but concern the allocation of land as a scarce resource, the defence of the town or the design responses to topography. Many towns we think of as organic originated as planned settlements and have since been infilled and reworked so that the basic planned pattern is no longer evident.

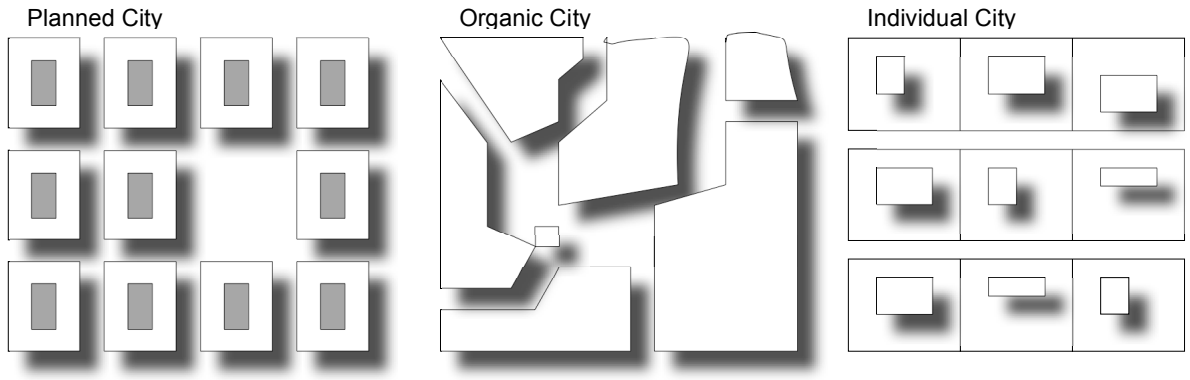


Figure 1 – City Types

Individual: Over the last one hundred and fifty years, towns have been affected by the growth of energy, water and transport grids. This has allowed them to become more dispersed and achieve lower densities. The common form has become the "pavilion" - the single building surrounded by open space. This applies to housing in suburbia, to commercial buildings on office parks, to retail malls surrounded by parking. This trend has meant that: the street as an enclosure disappears; the block gives way to the individual pavilion; open space is not in the controlled form of the square but is just the space left over between buildings; individual works of architecture are emphasised; the social dimension of the town is diminished

3. WHAT SUSTAINABILITY PRINCIPLES APPLY TO TOWN DESIGN?

In the past, cities developed rule systems to guide development. These were rarely concerned with aesthetics but would seek to regulate the use of a scarce resource (space along a canal, access to daylight etc.) or provide safety (height restrictions on tenement buildings) or ensure access (road widths) and so on. Just like a board game, the selection of rules determines the flow of play and a city has its character and form determined by the often simple rule set that it has adopted. The challenge for ecological urban design is to identify rule sets that improve environmental performance while contributing to the social and economic life of the city. Principles that should be taken into account in establishing such rules are:

Design with Climate: Key aspects of designing with climate in Northern Europe are concerned with protection from the prevailing wind and optimum solar orientation in order to gain energy efficiency and also the creation of sheltered outdoor spaces. Planting of trees can assist in the creation of a more benign climate, reduce wind around buildings and hence their thermal performance. Tree-shelter also contributes to enhancing biodiversity. Soft landscape and porous paving reduces the amount of standing water and also delivers energy benefits.

Wind: Wind can be seen as both a problem and an opportunity. As a problem it creates a chill factor to the fabric of buildings, it increases ventilation heat losses, it drives people indoors for longer and it causes people to drive rather than walk. Wind is however also an opportunity in terms of assisting natural ventilation strategies, but it can be exploited as an energy source.

Sun: As a general principle passive solar energy should be available to every building. Solar access should be a first consideration in driving a layout strategy. We would not recommend, however, that buildings be laid out in serried ranks facing south. Where a site is not particularly well positioned for passive solar design - sloping away from - or shaded to - the south - a combination of appropriate massing and planted shelter delivers significant benefits.

Rain: Whilst water shortage would not seem to be a natural area of immediate concern for many parts of Northern Europe, the collection and filtration to potable standards of water supplies is a financial consideration, when the bulk of this water is used for flushing WC's. It is worth considering the collection of rain locally (e.g. on roofs) for "non-potable uses". The SUDs (sustainable Urban Drainage) principles should apply whereby, in the interests of avoiding land and sewerage flooding, rain is retained for as long as possible and kept away from drainage. This will increase the proportion of soft landscaping over hard surfaces.

Shelter: The most appropriate form for many cities is one that offers shelter at the human scale and does not encourage wind eddying. Detached houses have a poor thermal performance and the terrace is a more common urban form. Creation of a microclimate through the linked design of planted shelterbelts and built form can contribute savings of 15% (plus) on energy use and improve amenity by reducing wind around buildings and the wind chill factor.

Density and culture: Cities can combine high quality with high density. However there has never been a complete and finite piece of work to back up or refute a general assumption that high density is environmentally sound because it has a tight footprint - physically. The interesting impact however is the non-physical impact. How far does the water come? From where does the food derive and how much transport is involved in feeding the beast? The effective footprint of a city extends far beyond its boundaries. Sustainable urban design should seek to minimise the transport generation and resource take of the city.

Massing and energy efficiency: Both theoretical studies and measured feedback have established the value of grouping buildings to achieve energy conservation benefit. For example an apartment in the middle of a block of flats with only one external wall has a threefold advantage in terms of external heat loss surfaces over a detached house. The diagram below shows the ratio of surface area to volume for various unit configurations.

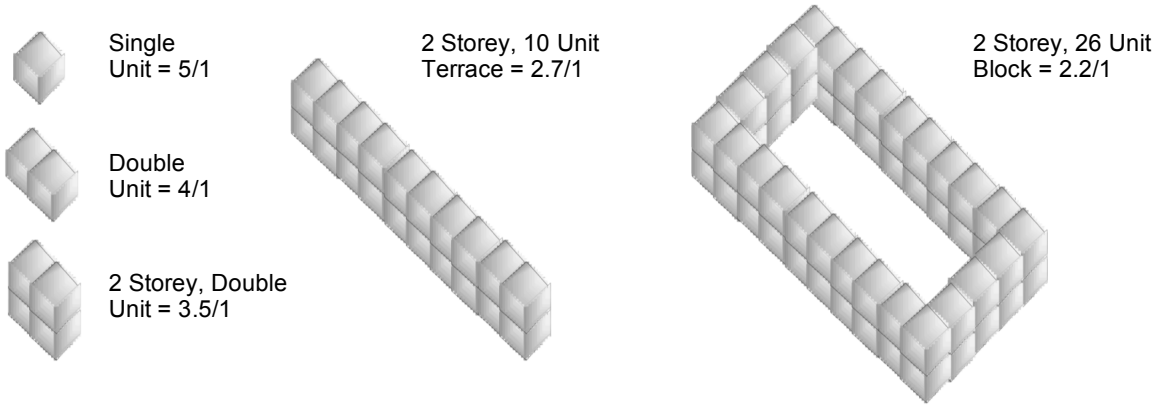


Figure 2 - Surface to volume ratios

The exposed surface area reduces relative to the volume contained as the forms tend towards traditional street and block forms. The pavilion form prevalent in modern planning (examples: Milton Keynes, suburban Edinburgh, Manhattan etc,) is the worst performer in terms of potential heat loss or solar gain. Extending the pavilion form upwards gives less of a benefit than extending it into a terrace, as the same configuration "on its side" will always perform better than "on its end". The implications for land take and therefore for dispersal are similar. The structure of urban land ownership leads developers to build upwards on the land they have. The same total volume of building organised over a number of adjacent sites will allow

more options in terms of building height. In the UK, we don't build at densities over 500 persons per hectare. We also generate areas of open space around pavilion forms through building regulations and planning requirements. The result is that maximum densities can easily be reached using traditional street and block forms in situations where we can aggregate land ownership. (see Martin and Marsh's studies of height and density in Manhattan, also March and Trace's work on efficient building forms for sun penetration – the 4 storey courtyard being the best performer.)

So the forms generated by designing for better heat loss performance and for higher density and greater compactness are not those of the modern pavilion. Making efficient use of land and energy would lead to much more traditional layouts. When we bring shelter into the equation, the argument becomes even stronger.

In general this then leads back to: the street, the block, the square - and the development of programmes of activity in public places coupled with emerging major effects on the relative roles and form of suburbs and centres brought about by the information revolution. But many in the architectural profession are wedded to the "pavilion" aesthetic. Sustainable design is not seen to be legitimate unless it reinforces "modern forms". Adopting traditional forms for the good reason that they arise naturally from the sustainable development agenda is often not accepted.

The Tyranny of the New

Gaia Planning is involved in the 'EcoCity' project – a programme that involves 11 year-olds in the design of an environmentally friendly city. Around 40 primary school children construct a large model that demonstrates ecological design principles applied at the scale of urban design. This has been run several times in Edinburgh and also in Belfast and Glasgow. The Royal Town Planning Institute has adopted it as part of its conferences in these cities.

When asked to run the EcoCity programme for second year students in a Scottish school of architecture, we followed the same process used with 11 year olds. The initial work with the students was very difficult. They insisted on creating arbitrary, geometric forms for the planned urban area and did not easily grasp the basic principles that primary school children took in their stride. Eventually the principles of ecological design were assimilated by the students and a much more subtle approach to urban design emerged. They enthusiastically completed the model on day four and presented their creation to the staff for comment. The staff were almost universally critical. "How can this be an expression of green principles and a new approach to urban design? – It looks like an old town!" And indeed it did. The basic principles of energy conservation, shelter, mixed use, compactness, materials conservation - and so on - had created a town that looked very traditional. Streets, blocks and squares formed the basic elements and the pavilion forms of modern architecture were generally disregarded, to the dismay of the staff.

This episode illustrates a major problem in applying the ecological agenda to urban design. The results will often look traditional. It should not be surprising that the myriad of designers of the traditional town fabric were actively trying to minimise energy loss, conserve material, deal with water, provide shelter and create a human scale. That was part of the culture – "the way things simply evolved". Architecture has become somewhat transfixed by novelty. Whilst not actively promoting pastiche, we do note that it is often the case that if a design does not look novel it is deemed to be reactionary, an attitude might not matter too much if it did not also have such an adverse effect on the ecological design of cities. The icons of modern architecture are all too often single pavilion buildings seen 'in the round'. The

processes of modern finance and development have also led to a concentration on the maximum development of individual small plots of land in the city. These two factors have produced the modern high-rise city, which looks dense while actually giving over large areas of land to circulation. Martin and March demonstrated that this is an illusion. Manhattan can be rebuilt at the same density with six-storey buildings with a reformed street pattern and perimeter forms. As with the fairground trick of trying to throw a dart at a gridded pattern of cards, there is actually more space between the buildings than in the buildings themselves.

City form in the past has been the product of what might be called 'immediate need'. People built in response to fairly short term imperatives and local conditions. City form is now driven by 'referred need' – by organisations that are not local and which have imperatives that are not derived from the local area. There is little interest in the development of an area as a whole except in so far as it may help to maximise development profit. An ecological approach suggests a return to more traditional urban forms. We need to identify the funding and organisational arrangements that will let this happen.

4. CASE STUDIES

Viikki

In a seminal competition study for Viikki near Helsinki, Gaia looked at optimising a number of eco-design aspects. Bio-climatic design from solar, wind, rain and snow data was investigated and appropriate forms were evolved. Higher storey heights to north and lower (non-domestic) forms to south gave solar access and, when combined with strategic tree and shrub planting, also sheltered areas formed naturally as courtyards. Soft landscaping - complemented with a surface water management regime that included a pond - was sized to be of optimum value to the built form. This city block doughnutted round a green focal point. Street widths were determined by the need for winter snow-clearing between path and road, where tree planting brought scale to the otherwise wide street, on the obverse of the blocks. This also created sheltering wind lift over the roofs. The formal proportions at 4 storeys are similar to those of the Prisma project at 9, i.e. about half its scale. The blocks were strung together along an axis street never more than 4 wide - reducing scale to the edge. This gave a linear city form with access to green open space being always close to any point of the development.



Courtyard housing block proposed for Viiki ←



Plan of development at Regenbuåsen ←

Regenbuåsen

The Viikki form had been pioneered for the Gaia winning competition entry at Bergen-Regenbuåsen, only in a more organic format whereby the blocks snaked around a very

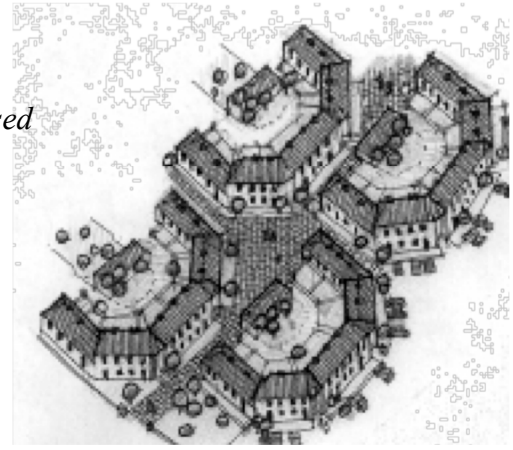
challenging topography. The key aspect of this proposal lay in its holistic and permacultural approach, which involved the design of the community participation methodology, and the land management regime - including extensive horticultural areas, as well as the physical layout.

The Sunscoop at Perth

The Fairfield Housing project comprises refurbishment of 400 urban fringe houses in Perth, Scotland. Evolving over 18 years with an increasing agenda of sustainability the project is a mixture of refurbishment and newbuild. The most recent newbuild phases have used a sunscoop form - taken from the permaculture principles relating to solar access - which create a crescent form low to south and high to north. What has been appreciated since the completion of the project five years ago - is that the heat of the sun is retained within the courtyard throughout the daylight hours and on into the evening. The form is also complemented by planting and adjacent housing, which together assist in the sheltering of the court from wind.



Sunscoop forms used to form street in Orkney ➔



← *Sunscoop housing in Perth*

Orkney new forms + old

In a current masterplanning exercise for 120 houses in Kirkwall on the Island of Orkney, we are extending our experience of the use of the sunscoop form. It is a combination of the Viikki, Bergen and Perth projects. It takes its licence for a high density sheltered street from the narrow main street of Kirkwall, and like the Viikki design it feeds from this spinal street out via an urban block form to open land at the perimeter of the site. Every piece of soft landscaping is utilised. Where the option for gardens adjacent to flats is tight then allotments are placed at the end of the blocks and adjacent to the peripheral car parking. Even so the walking distance from cars to front doors is in no case more than 30 metres.

Prisma project Nuremburg - solar urban island

The work of architect Joachim Eble has been devoted to the construction of urban ecological settlements. The most dense and complete of these is at Nuremburg in southern Germany. He has dubbed this a “Solar Urban Island. It is a mixed-use development going at its highest point to 9 storeys. The ground floor comprises shops above which are three storeys of offices which open onto a glazed “wintergarden” - which is naturally conditioned by the use of flowing water and mature plants - including trees. Above this are the apartment blocks. The development comprises the whole of a major city block and has its own kindergarten feeding onto a wild nature garden, with a pond that doubles as the store for the air conditioning system. Yet again the optimum in this very high-density development is in the perimeter medium rise rather than the tower block. Despite its height it manages via its proportions and the provision of a semiclimatic zone under glass to achieve a human scale.

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Environmental drivers, management and results in Swedish building industry. A survey within the International Business Environmental Barometer.

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1. INTRODUCTION

The building sector is often described as the ”40% sector”: This is a way to point out the environmental importance of the building sector. Although several studies describe the overall environmental impact of the industry (BKR 2001, VTT 1998), less is known about how the industry tackles the environmental issues. To learn more about the industry’s environmental strategies, a questionnaire survey directed at the Swedish building industry was carried out in April/May 2002. The survey was carried out within the context of the International Business Environmental Business Barometer (IBEB), which is an European network that conducts questionnaire surveys of the state of environmental work in industry in different countries. The surveys study industry’s definition of its environmental challenge, its response and achieved results in different countries.

2. THE INTERNATIONAL BUSINESS ENVIRONMENTAL BAROMETER

The International Business Environmental Business Barometer (IBEB) has measured the state of environmental management in industry since 1993. It is repeated every two years. In the beginning, only the Nordic countries took part in the survey. By now, the IBEB network has grown to include around 10 European countries. A standardised questionnaire is the basis in the IBEB surveys. It has been developed over the years, so questions (wording, scales, etc) has changed somewhat since the beginning, but the basic structure is much the same (see fig.1).

2.1 A Business Environmental Barometer with focus on the Swedish building industry

Originally, the IBEB covered both the manufacturing and the service industry. The growth of the IBEB network has led to a focus on manufacturing industry, which is why the IBEB has not been directed to the building industry since 1997. According to general industry categorisations, the building industry is part of the service sector. However, the environmental importance the building sector has led us to complement the 2001 Swedish survey – the

Swedish questionnaire of 2001 was used again in a separate survey to cover the Swedish building sector. A similar complement is underway also in Norway (Ytterhus 2002).

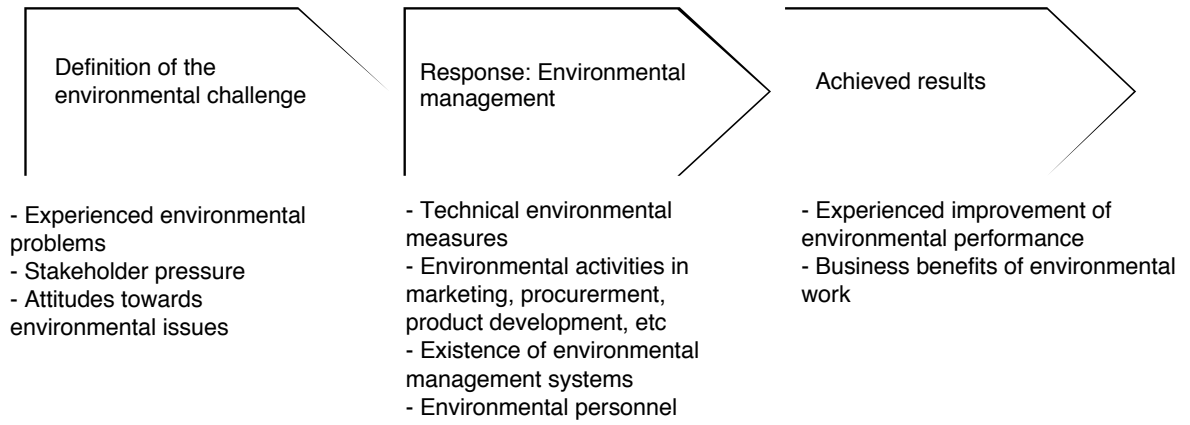


Figure 1 General structure of the survey.

2.1.1 Preparation of the questionnaire. The Swedish IBEB questionnaire of 2001 was used, with some small changes, in our separate survey of the Swedish building industry. More service-oriented wording (e.g. 'product/service' instead of 'product') and sector-specific terminology was introduced (e.g. 'tenant organizations' instead of 'consumer organizations').

2.1.2 Statistical population. The survey covers *all* companies with at least 50 employees within architecture, technical consultants, building contractors, property managers and demolition (manufacturers of building materials were included in original Swedish survey). According to the Swedish Statistical Office, there are 544 companies with their main business is one of these categories, see also table 1.

2.1.3 Organization of the survey. The questionnaire, together with an introductory letter, was sent out to each company in the statistical population at the end of April. Addresses were obtained from the Swedish Statistical Office's company register. After three weeks, a reminder was sent out (in mid-May). Responses are collected until the end of May.

3. PRELIMINARY RESULTS OF THE SURVEY

3.1 Response rate

So far (as of May 15, 2002), a response rate of 21% has been reached. Since questionnaires are collected until the end of May, results presented in this paper are preliminary.

Table 1 Total number of companies, response frequencies and response rates.

	Total number of companies	Responses (as of May 15)	Response rate [%]
Contractors, building entrepreneurs	262	44	17
Property owning companies	97	32	33
Property management companies	48	8	17
Architects	7	2	29
Technical consultancies	112	24	21
Demolition companies	18	4	22
Total	**544**	**114**	**21**

3.2 The environmental challenge as perceived by the companies

The environmental challenge is defined by how the companies see themselves contribute to environmental problems and how they experience environmental pressure from stakeholders.

3.2.1 Environmental problems. Most companies see the use of energy as their most serious environmental problem and the use of toxic substances as their least serious problem (see figure 2). Many also feel that they have no impact on land-use-related problems (landscape damage, soil contamination).

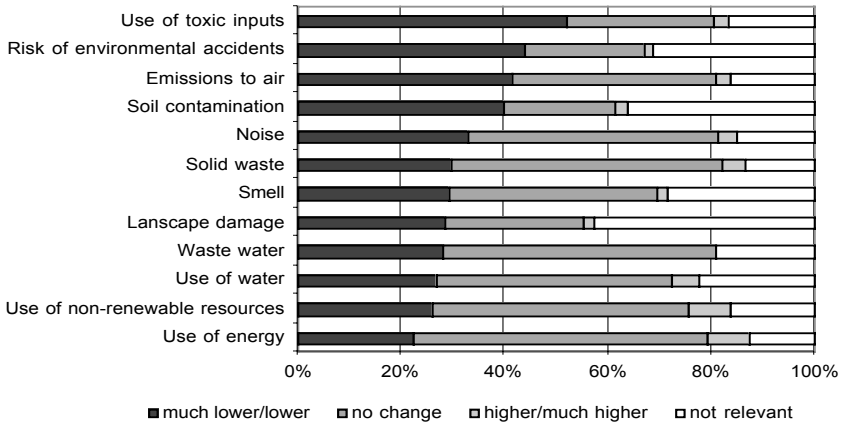


Figure 2 Companies' rating of their contribution to various environmental problems relative the industry average.

3.2.2 Stakeholder pressure. Clients are the environmentally, most influential stakeholders in most companies (see figure 3). It seems that customers (clients and tenants) generally are environmentally more influential in the building industry than in other industry sectors. In the Swedish Barometer, managers and environmental authorities are the most influential categories. Business clients and consumers rank 4th and 10th, respectively (Nilsson and Hellström 2001).

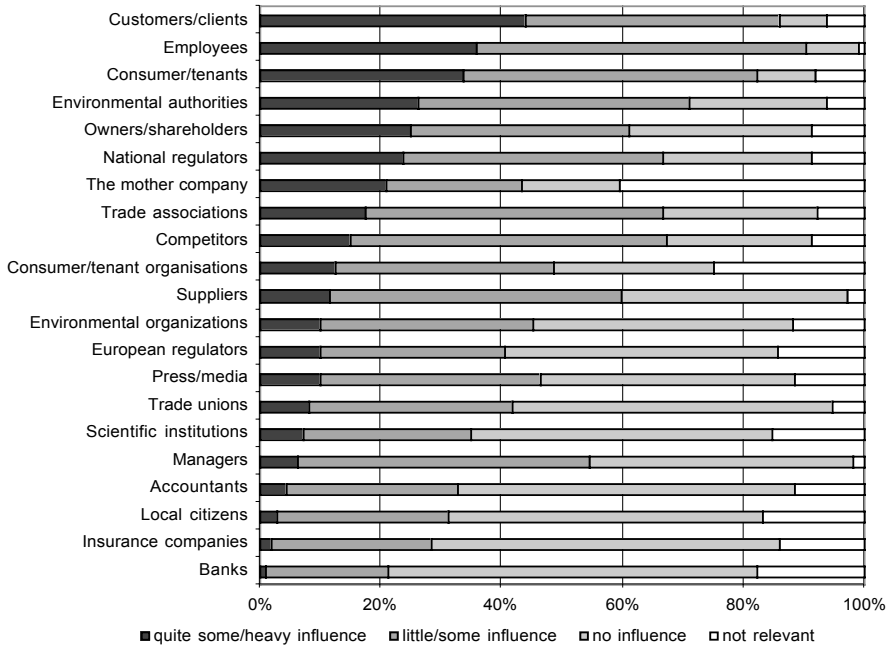


Figure 3 Companies' rating of stakeholders' influence on environmental activities in the company.

3.3 The companies' response to the environmental challenge

3.3.1 Technical measures. Waste separation is by far the most common measure to reduce environmental impact in Swedish building industry (see figure 4). Energy reduction measures are more common in other industry sectors than in the building sector in Sweden (56% and 36%, respectively) (Nilsson and Hellström 2001). This is surprising given the importance of energy issues in the building industry.

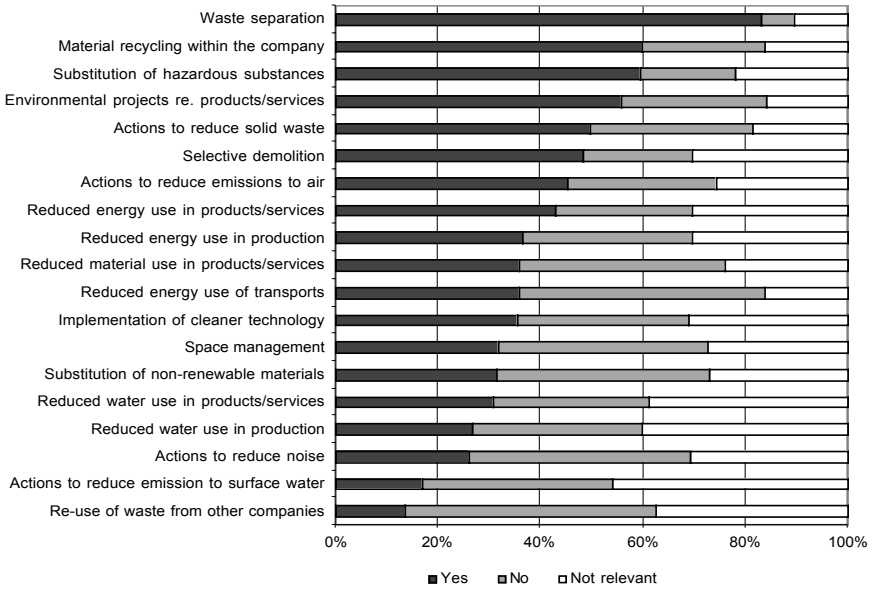
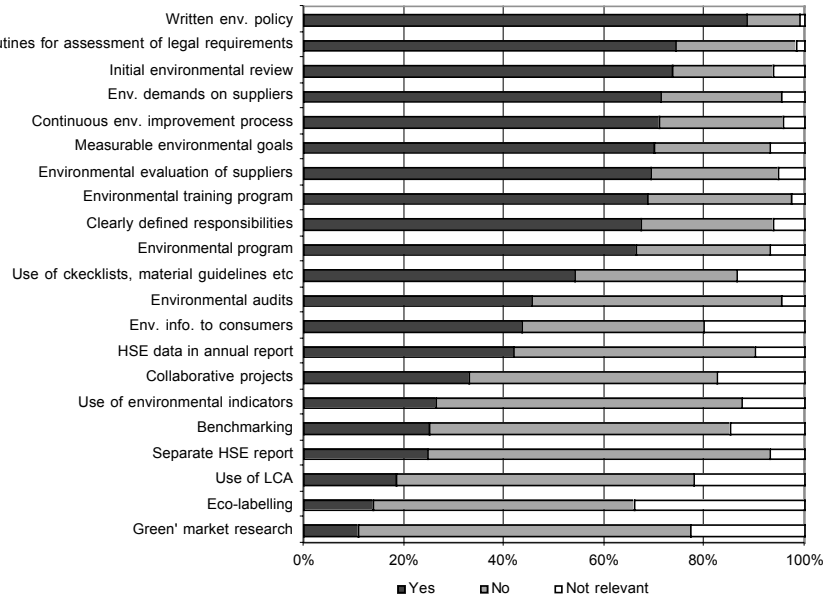


Figure 4. Environmental activities of a technical nature in the companies.

3.3.2 Managerial measures. Environmental management systems (EMS) dominate among management-oriented activities (see figure 5). The survey also shows that around half of the companies has an EMS. The number will increase as many are in progress of implementing an EMS. Environmental work has a qualitative quality: e.g. relatively few use environmental



indicators even if many work with measurable goals, and checklists are preferred to LCA.

Figure 5. Environmental management activities in the companies.

3.3.3 Obstacles. The lack of market incentives is the most pronounced obstacle in the Swedish building industry (see figure 6). On an overall level, the building industry experiences obstacles more pronounced (between 5 and 10% more) than in other sectors in Sweden, especially when it comes to regulation and willingness to cooperate.

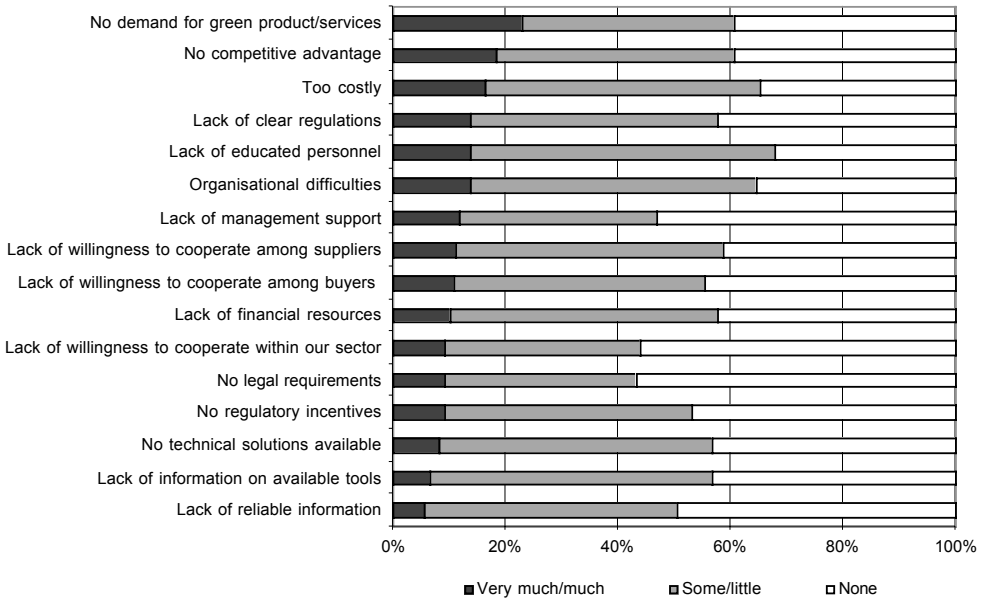


Figure 6. The extent which obstacles have influenced environmental activities in the companies.

3.4 Results of companies' environmental activities

An indication of the success of the environmental work is obtained by looking at what extent environmental activities have had effect on environmental performance and business.

3.4.1 Environmental improvements. Environmental activities have had most impact on the use of toxic substances, solid waste and energy use (see figure 7). Apart from energy use, the results are in line with figure 4 which shows that waste separation and substitution of toxic substances are common activities in the industry. To compare, around 10% more companies say their work has had a large effect in the Swedish Barometer (Nilsson and Hellström 2001).

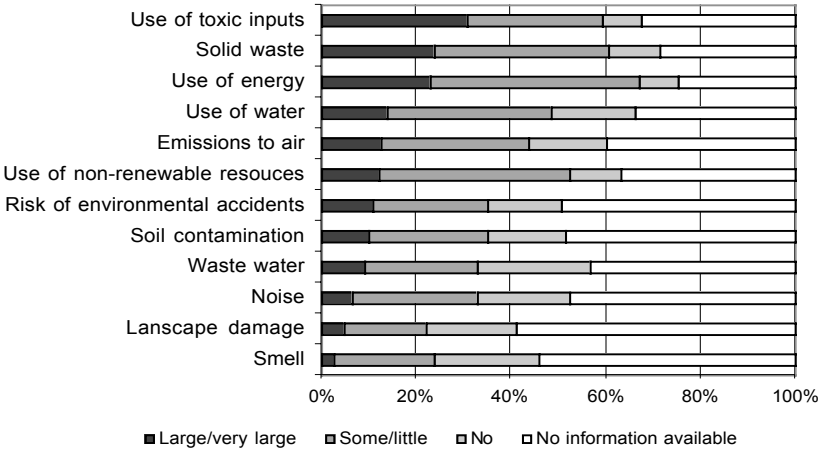


Figure 7. Effect of environmental activities on environmental problems

3.4.2 Importance for business. Similar to other industry sectors (Nilsson and Hellström 2001), companies in the building sector see that environmental activities mostly bring a long-term benefit to business. 60-70% of the companies answered that environmental activities have had a positive impact on company image and long-term profit, whereas 12-15% said that environmental activities have had a negative impact on profits, cost savings and productivity.

4. ANALYSIS

4.1 Focus of environmental action. There seems to be a slight preference for environmental activities of a managerial kind in the Swedish building industry. A comparison of figures 4 and 5 shows a higher percentage of engagement in environmental activities of a managerial kind than technical ones.

4.2 Comparison of Swedish building industry with other industrial sectors

Generally, the surveys of the Swedish building industry and Swedish industry (Nilsson and Hellström 2001) show many similarities. However, environmental activities seem to be more externally controlled in the building sector. Clients and tenants are seen as more influential in the building industry than clients and customers in other sectors. The most striking difference is that while managers are among the most influential stakeholders in Swedish industry, they are pointed out as one of the least influential groups in the building industry (1st and 17th, respectively). Also, there are difference concerning obstacles and environmental effect of activities: obstacles are somewhat higher and effects of activities are somewhat smaller in the building industry. Nevertheless, environmental work brings the same type of business benefits to companies in the building sector as in other sectors in Sweden.

4.3 More analysis…

A more detailed analysis will be performed when the survey has been closed after the end of May. Apart from updating the results in this paper, differences between architects, technical consultants, building contractors, property managers and demolition companies will be studied as well as the effect of company size, etc on responses.

5. CONCLUSIONS

Energy issues are seen as the main environmental challenge in the Swedish building industry. The way the Swedish building industry responds to the environmental challenge is mainly with environmental management activities (environmental management systems) and with waste separation. Obstacles are somewhat higher in the building industry than in other industry sectors, which may account for the somewhat lower effect of environmental activities to reduce environmental problems. Nevertheless, the business benefits of environmental work are on the same level in building industry as elsewhere.

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Hugh L. Carey Battery Park City Authority
High-Rise Residential
Environmental Guidelines

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1. INTRODUCTION

Battery Park City is a mixed-use planned community on a landfill site, at the edge of Lower Manhattan, adjacent to the former World Trade Center in New York City. Its location takes advantage of the existing infrastructure and public transportation system. Planning of Battery Park City began in the 1960's; installation of the landfill was completed in the 1970's, and development of the site began in the 1980's.



The community is being developed by a public benefit corporation, Hugh L. Carey Battery Park City Authority, according to a master plan, in a model of public/private partnership. Infrastructure and parks are built by the Authority and individual building parcels are developed by private developers according to Design Guidelines and Environmental Guidelines issued by the Authority.

Under the leadership of Governor George E. Pataki, a policy to require that all future buildings in Battery Park City be developed in an environmentally responsible fashion was adopted in 1999. In January 2000, the Hugh L. Carey Battery City Authority issued its Residential Environmental Guidelines. Like the Urban Design Guidelines, the Green Guidelines are prescriptive, enumerating a list of 65 separate requirements that a developer must meet. The requirements are ultimately grouped by common goals: energy efficiency; indoor air quality, material and resource conservation; operations and maintenance; and water conservation.

Through the Authority's Green Guidelines developers, architects, engineers, contractors and building trades industry professionals will be exposed to the concept of environmentally responsible development for projects both within and without Battery Park City. The selection of the Albanese Development Corporation (working with Cesar Pelli Architects) as developer for the first sustainable residential high-rise was based not only on its financial proposal to the Authority but also on its approach to the environmental requirements and the proposed building design.

2. RESIDENTIAL ENVIRONMENTAL GUIDELINES

2.1 Origin

Battery Park City Authority originally met with The New York State Energy and Research Development Authority (NYSERDA), a state entity whose mission it is to assist private and public organizations to achieve greater energy efficiency, and the National Resources Defense Council (NRDC) to discuss the feasibility of sustainable high-rise residential development. The Authority found that there were no existing guidelines or rating system that dealt with high-rise residential buildings, therefore, Battery Park City Authority needed to develop and issue its own.

2.2 Team

Working with Fox and Fowle Architects, (the firm responsible for the 4 Times Square office building) the Authority assembled the team of Flack and Kurtz Engineers, Green October, Rocky Mountain Institute, Carrier Corporation, Barney Skanska USA, and NYSERDA to develop our Residential Environmental Guidelines.

2.3 Intentions

The stated mission of the guidelines is to establish a process for the creation of sustainable residential buildings.

2.3.1 Sustainable Design

Sustainable design is defined in our guidelines as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." This approach decreases dependency on non-renewable resources while improving opportunities for self-sustaining alternatives that are both more efficient and more economical.

2.3.2 Market Strategy

Incorporating sustainable principles in the development of the residential buildings serves to enhance the current marketing strategies that continue to make Battery Park City a successful

endeavor. Proper materials in conjunction with providing increased mechanical ventilation and a filtered fresh air system create a healthier living environment.

2.3.3 Comprehensive Approach

A comprehensive approach, covering essentially all aspects of the building is the fundamental philosophy of our guidelines and the best approach to achieving the desired result in a cost effective manner over the life of the building. A financial goal of this comprehensive method is to minimize increased construction costs. For example, the cost of improving the performance of the exterior envelope of the building may be offset by a reduction in the size and subsequent cost of mechanical equipment.

2.4 Requirements

The five goals: energy efficiency; indoor air quality, material and resource conservation; operations and maintenance; and water conservation are divided into a total of 24 general intents. These intents are followed by 65 specific requirements.

While some of the requirements are prescriptive, others are purposely goal oriented to provide for creative solutions to environmental problems while not precluding rapidly changing technologies or conflicting with evolving policies, regulations and building codes. For each requirement or group of related requirements, "the guidelines" sets forth strategies to meet that requirement, cost implications of meeting the requirement including first costs and payback periods, and funding sources. Some items are common sense, some add no additional cost and others are new and more expensive technology. Expensive initiatives such as water treatment will become more important and cost effective as time goes by.

The five comprehensive goals with underlined intents are listed below. Following each of these goals are some of the numerous requirements.

2.4.1 Energy Efficiency

Maximize Energy Efficiency- Increase energy efficiency by 35% over the current New York State energy Code.
Modeling for Energy Performance- Use the U.S. Department of Energy's (DOE) DOE-2 as a design tool to forecast energy performance and reduce operating costs.
Renewable Energy- Provide space allocation for future fuel cell and use integrated photovoltaics that contribute 5% of the base building electrical load.
Green Power Sources- Use power from alternative fuel sources and/or renewable powersources.

2.4.2 Enhanced Indoor Environment Quality (IEQ)

Indoor Air Quality (IAQ)- Provide ducted outside fresh air filtered to remove 85% of particulates by means of mechanical ventilation.Select Low Emitting Materials- All adhesives, paints and coatings must meet the volatile organic compounds (VOC) limits in "the guidelines."
Controllability of Systems- Increase occupant control of HVAC and natural ventilation system to support optimum health and comfort.
Lighting & Daylighting- Increase ceiling height to 8'-6" and increase natural light by 30% over New York City Building code.
Indoor Pest Control- Develop a pest management plan.

2.4.3 Conserving Materials and Resources

Storage & Collection of Recyclables- Provide a dedicated and ventilated room with separate waste and recycling chutes.
Construction Waste & Resource Reuse- Recycle 60% (by weight) of construction waste.
Recycled Content- Use 50% (by cost) of materials listed in the Environmental Protection Agency's guidelines.
Local/Regional Materials- Use 40% of all building materials (based on cost) that are manufactured within a 500-mile radius of the project.
Renewable & Rapidly Renewal Materials- Use material such as bamboo or wool where applicable.
CFC (chlorofluorocarbons) Elimination- Use HVAC (heating, ventilation and air conditioning) equipment with no CFCs and develop a "phase-out" plan for equipment with HCFCs (Hydrochlorofluorocarbon).
Alternative Transportation- Provide bicycle storage for 5% bicycles per apartment.

2.4.4 Operations & Maintenance

Full Commissioning- Establish a commissioning team during design and prepare a commissioning plan.
Building Systems Monitoring- Provide an air quality profile for each apartment.
Maintenance Accountability- Prepare a maintenance manual.

2.4.5 Water Conservation and Site Management

Storm Water Management- Provide for the collection of 100% of all roof rainwater.
Innovative Water Technologies- Treat and recycle graywater with natural filtering technology.
Water Use Reduction- Minimize the use of potable water.
Water Efficient & Responsible Landscaping Practices- Use non-toxic pesticides, herbicides and fertilizers.
Landscape and Roof Design to Reduce "Heat Islands"- Plant 75% of all open roof area.

2.5 Implementation

The building, construction, which began in March of 2001, will include a central hot water system for heating and cooling fueled by a natural gas absorption chiller, a black water system (only a graywater system was required) for treatment of toilet, lavatory and shower water and the infrastructure to accommodate a fuel cell. The required photovoltaics will be integrated into a typical residential building façade. The building will maintain the design integrity of the planned community, while moving environmental technology forward.

3. CONCLUSION

With the continued destruction of the world's natural resources through development, sustainability is attracting a larger constituency. While the initial costs of environmentally responsible development may be higher, end use savings are increasing. During early discussions regarding residential high-rise sustainability, skeptics were warned that developers would not be willing to pay more for sustainability. Much to their chagrin, nine developers vied for the rights to build on the first site encumbered with Green Guidelines. Since then, two more

"green" building sites have been released and developers were selected. This overwhelming response showed that the New York residential development community was open to change.

For sustainable residential high-rise development to be successful, it is essential that the developer and architect be totally committed to sustainable design and begin their planning at the pre-schematic design phase of the project. It is important to note that the comprehensive approach to sustainable design in New York City increases the construction cost. This total approach requires, for example, the expensive treatment and recycling of water (with no payback) in an urban context where water is normally plentiful and inexpensive. However, the current drought emphasizes the importance and future need for water recycling.

Battery Park City Authority's leadership role at the forefront of environmentally responsible development is aided by its use of the competitive bidding process for development rights. As a result of this process, "green" developers are not at as much of a financial disadvantage in competing for development sites as they may be elsewhere in the city. However, given the heightened concern over air quality, water quality and energy costs, there is a greater possibility that tenants will pay a premium for a "green" apartment thereby offsetting construction costs until sustainable development becomes standard practice.

The "Mischek Oekopass": Austria's first Building Certificate securing Qualitity and Comfort in Apartment Buildings

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1. INTRODUCTION

The construction, use and disposal of buildings cause costs, mass flows, energy consumption and emissions. These environmental burdens and financial costs can be reduced by adequate planning and quality assurance tools, which improve the built quality and therefore increase the property value.

Many building passes have been developed in the past years, f .e. "Rating e-top" (Switzerland), "LEED" (USA), "BREEAM" (UK), "C-2000" (Canada), "Eco-Profile" (Norway), "Eco-Effect" (Sweden), Escale (France)" ([1], [2]).

The "Mischek Oekopass" is Austria´s first building certificate for apartment buildings. It was developed by Mischek, Vienna's leading developer and builder of residential buildings together with the IBO – Austrian Institute for Healthy and Ecological Building. In October 2001 it was issued for the first time. Since then several other Mischek apartment buildings have received the Mischek Oekopass. Mischek's goal is to issue this building certificate to all its buildings.

2. OVERVIEW AND DISCUSSION

The Mischek Oekopass makes clear statements easily understandable for all non-experts about the quality of an apartment building. Key criteria are defined to evaluate the inhabitant comfort, supplemented by the ecological properties of the building. In pre-assessment and final assessment a total of eight key criteria are reviewed, which are decisive for the inhabitants comfort:

- Indoor air quality: Chemical analysis of a wide range of indoor air pollutants, esp. organic solvents. In addition indoor air mould spore concentrations and air tightness (with a blower door test) is checked.
- Comfort in summer and winter: sunlight protection, thermal insulation, comfortable indoor surface temperatures
- Acoustic properties: airborne sound, footfall sound and background noise are measured
- Electromagnetic properties: measurements of electromagnetic burdens by electrical installations and mobile phone transmitters

- Sunlight and brightness: brightness and direct sun light in the main living room
- Ecological properties of the building construction and materials
- General energy concept of the building for heating and warm water (efficiency, energy source)
- Water use: measures for an efficient water use, use of rain or well water, % of permeable surface

The Mischek Oekopass assessment is done in two stages:

- A pre-assessment is conducted at construction site start, which is usually also when the marketing of the flats starts. The pre-assessment is based on all planning documents as well as experiences gained from earlier evaluations of Mischek buildings.
- After completion of the building and before the tenants move in the final assessment based on measurements is made. Three ratings – based on a challenging criteria system - are possible: "very good", "good" and "checked".

Only if an apartment building has been rated in all criteria with "checked" as a minimum, the IBO issues the "Mischek Oekopass".

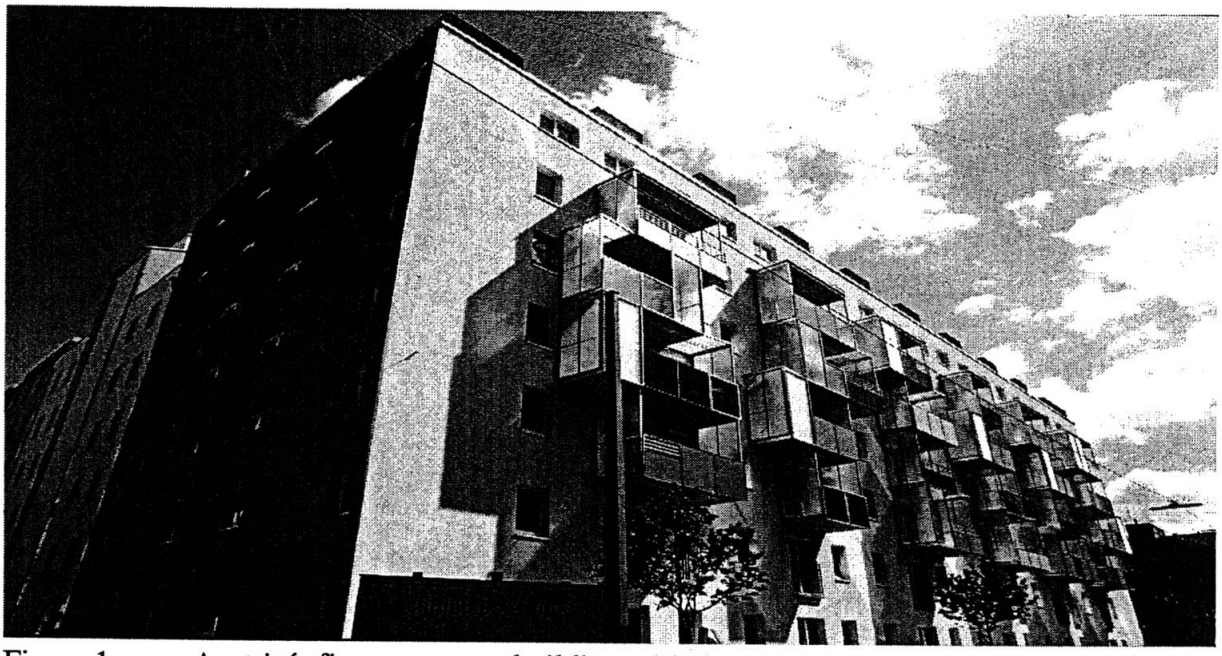

Figure 1 Austria´s first apartment building with the Mischek Oekopass building certificate is located in Vienna´s 20th district (address: Treustrasse 84).

Focus on the key Criteria

The Mischek Oekopass focuses on few criteria to keep the building certificate easy understandable and meaningful at the same time. Among the criteria that are not being considered are:

The site specific factors infrastructure and transportation:

The location of an apartment building and its infrastructure can hardly be influenced by a builder. The decision, whether one wants to live in the green outskirts of town or in the probably noisier inner city area is a very personal one and can only be taken individually. One thing builders can do is to influence traffic by facilitating bicycle use by f. e. planning accessible storage rooms for bicycles.

RECYCLABILITY

Due to the long service life of a building, recycling properties are hard to determine. Nevertheless this criteria is included in criteria of the ecological properties of building materials

CONSTRUCTION SITE LOGISTICS

Waste separation and waste management standards are legally regulated. However, measures like Mischek´s rail-based construction site delivery system for prefabricated concrete components are assessed as a CO_2 reducing activity as part of the building material evaluation.

MAINTENANCE COSTS

Energy and water consumption are key criteria in the Mischek Oekopass evaluation. Other costs like waste management fees are currently charged without correlation of the actual waste volume. From supplied figures for energy and waste consumption tenants can easily calculate future running expenses for their new home.

MISCHEK OEKOPASS – A QUALITY CONTROL TOOL

The Mischek Oekopass is the first building certificate issued in Austria. The results bring important findings for the implementation of ecological building criteria in large scale apartment buildings. It helps developers to identify strengths and weaknesses in their planning. Measurements of finished buildings help builders secure the planned specifications. Building trades are forced in turn to improve their work. For example, the random test measurements of acoustic properties have lead to more efforts to secure high quality construction work.

Another result is declining prices for low-emission glues due to the increased demand of the builder.

MISCHEK OEKOPASS – A MARKETING TOOL

The Mischek Oekopass of course also is a marketing tool. Customers are now being informed better and more comprehensive about the properties and quality criteria of their future apartment than before. This is why the City of Vienna awarded a prestigious price to the Mischek Oekopass, the "OekobusinessPlan Award 2002". The reason given by the jury was that this building certificate is the best example of bringing together marketing and communication with economical and environmental efforts.

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cFrom Road to Rail:
Mischek's Innovative Construction Site Logistic concept

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1. INTRODUCTION

There are many reasons to develop concepts, which reduce truck traffic. Austrian data underline the urgency. [1]

- The construction industry is responsible for about 30 % of the mass flow and the energy consumption of a national economy.
- 37 % of all Viennese CO_2 emissions from the transportation sector come from trucks.
- 50 % of all goods - by weight - transported by trucks are linked to the construction industry.
- Although only 1 % of all traffic kilometers are related to construction work, 7 –10 % of all NO_x and particle emissions have their source there.
- 99,6 % of all construction transports is by trucks.
- Vienna is expecting a 20 % increase in truck traffic till 2015.

Mischek is the biggest Viennese developer and builder of residential housing projects, about 1 000 flats in apartment buildings ranging from 10 to 250 units are developed annually. In the past three years Mischek has developed an innovative rail-based construction site logistic concept.

2. RESULTS

PILOT PROJECT: EXCAVATION & PREFAB COMPONENTS

In 2000 Mischek has successfully conducted a pilot project on a 58 flat residential building that - for the first time in Austria - shifted a major part of the construction transports from road to rail, from trucks to trains. Two major mass flows of this construction site were excavation material and prefabricated concrete parts. They together caused 86 % of the total mass flow. These two material flows were transported by train for most of the distance, just for the last kilometer between the construction site and the railway station conventional truck transports were used.

The results were impressive: Diesel consumption from excavation transports and prefab materials transports was reduced by 20 000 liter. This results in a reduction of CO_2-emissions by 58 tons CO_2 (74 %). [2] [3]

NEXT STEPS – PREFAB COMPONENTS

Since the end of 2000 Mischek has implemented the concrete prefab parts logistics in its daily operations:

- In 2001 about 40 000 tons of prefab concrete components - for about 500 flats - were transported by rail saving 67 000 l diesel consumption and 200 t CO_2 emissions.
- Till 2003 a total of about 120 000 tons of prefab concrete components (for 1300 flats) will be transported with Mischek's rail-based logistics concept. This will save an about 165 000 l diesel and 500 tons CO_2. [4]

Currently the rail-based system is slightly more expensive than conventional truck transport. Mischek is convinced to achieve at least a financial break-even in the next years. Therefore currently Mischek is investigating and implementing improvements to reach this goal.



Figure 1 Mischek´s rail based logistics system for prefabricated concrete components

NEXT STEPS – EXCAVATION MATERIAL

The excavation material transports at the 2000 pilot project were far more expensive than truck transports, therefore more research was needed to improve the concept. The research project RUMBA was initiated.

RESEARCH PROJECT RUMBA

In November 2001 the 3-year research project "RUMBA" started in Vienna, which is co-funded by the EU ("LIFE Environment" scheme). "RUMBA" is the german abbreviation for "Guidelines for sustainable construction site management". Mischek and the City of Vienna are the major partners in this project. [1]

A regulatory framework for environment-oriented building site logistics is to be drawn up by RUMBA in a cooperative process involving all major parties in the building industry. This should cover legislation, standards, regulations, guidelines, terms of tender, contracts, subsidies, issues pertaining to the location of building logistics centres and inter-company logistics cooperation, costs, technologies employed and organization. Coupled with this cooperative process, three demonstration projects in 2003 and 2004, designed to provide practical experience and proof of feasibility, are to be conducted:

- Shift of building site traffic from road to rail in a specific construction project: Shift at least 75 % of building site traffic from road to rail, reduction of climate-affecting emissions and air pollution by 60 – 85 %. Achievement of the financial break even for

the rail transport of shell materials and development of new logistics infrastructure for the transport of excavation material by rail.

- Property developer competition — "Environment-oriented building site management", to collate ideas and evaluate costs and feasibility. Relevant rise of environmental standards shall be demonstrated for a large residential complex with 200 – 1 000 flats.

For more information about RUMBA see *www.rumba.at*

3. CONCLUSION

The task to make train based construction site material transports (excavation material, gravel, concrete etc.) a daily standard is still very difficult, but feasible. The main problems are that today many internal costs are externalised (like CO_2-emissions / climate protection), more flexibility of the mostly state-owned rail operators is urgently needed to get cost-competitive services and prices and more demand for these environmentally sound rail-based service from the public sector – as an initiating impulse - is needed.

The experiences gained by Mischek in Vienna clearly indicate the huge gains that can be made when construction site logistics is integrated into the planning process at an early stage. Huge reductions of truck transports can be achieved, thereby cutting diesel consumption, CO_2 emissions and other air pollutants as well as noise.

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CHEM.RED.:
Reduction of harmful substances in the construction industry at Mischek, Vienna

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1. INTRODUCTION

Mischek AG is the biggest housing constructor in Austria's capital Vienna. The actual yearly output amounts to appr. 1000 apartments, partly associated with offices and corresponding commercial spaces. For several years now, Mischek follows a strictly progressive policy in improving housing quality and environmental performance of both construction and buildings. One of the projects in this context – internally labelled "CHEM.RED." is aimed at substantially reducing the amount and toxicity of potentially harmful chemical substances used and applied during the construction process.

In accordance with overall technological trends of the last decades, chemical substances play a crucial role in the construction process for Mischek as well as for others. By far the biggest concern relies to the important group of organic solvents (described as volatile organic compounds, VOCs in this paper). Their most common role is the simplification and acceleration of manifold construction operations, in most cases they evaporate during resp. after application, being thus subject for occupational, indoor quality as well as environmental concerns.

Impacts by organic solvents

Organic solvents (VOCs) used in housing construction pose a threefold serious threat to both human health and environment:

- In the first place, construction workers subject to organic solvent exposure risk chronic diseases esp. of the central nervous system and of nerves. Effects of long term exposure include nervous disturbances as physical and intellectual retardation, trepidation, nervousness, loss of sensitivity, chronic exposure may as well seriously affect internal organs such as liver and kidneys.

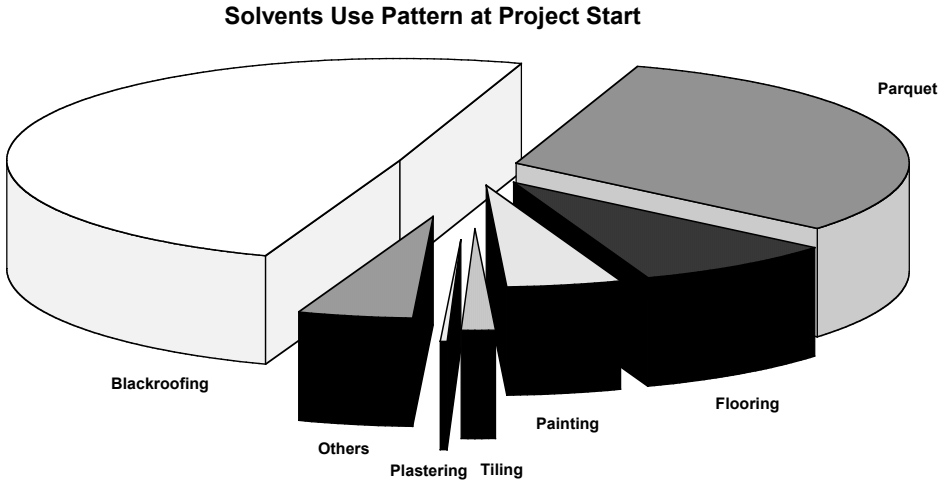
- Chronic exposure is also the case of people living in dwellings. In this case, cause-effect relationships are less clear identified, but the fact that one dwells in one's flat for a major part of one's lifetime, makes exposure to even smaller concentrations of indoor pollutants. Exposure to a mix of chemical substances contained in indoor air is one of the clear major sources of newly discovered chronic diseases like MCS (Multiple Chemicals Sensitivity), CFS (Chronic Fatigue Syndrome) or SBS (Sick Building Syndrome).

- Last but not least, VOC emissions from building construction are a relevant contribution to environmental problems such as Global Warming and the formation of photo oxidants ("summer smog").

Starting situation
When starting the CHEM.RED. project in 2000, an internal investigation on the use of solvents on Mischek construction sites showed an overall amount of approximately 17 kgs VOCs used per flat[1]).

The use pattern is demonstrated in Fig. 1. Most of the solvents are not used by Mischek itself, but by contracting companies. 94% of the total amount are applied by only four out of 47 identified individual crafts: blackroofing[2]),parqueting, flooring, painting:[3])

Figure 1: Solvent use at Mischek construction sites in 2000



2. RESULTS AND DISCUSSION
In 2000, Mischek decided to reduce the use and impact of organic solvents to the absolute minimum required for maintaining construction quality, while not exceeding excessive costs. This latter condition is not a result of an "environment: yes, expenses: no!" attitude but a unavoidable result of the fact that the lion's share of Mischek's dwellings is part of social housing programmes co-funded by the public, which are subject to legally binding strict cost limits per square meter.

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[1]) average apartment size 80 m²

[2]) This craft (usually comprised in roofing) is an Austrian peculiarity; the blackroofer (German *Schwarzdecker*) prepares all bituminous sealings in the building.

[3]) Use patterns depend largely on the design and equipment of the buildings. F.e. - while investigating VOC use pattern, no wooden constructions were established by Mischek; this is the reason, why the carpenter does not figure on the list of VOC contributors. Different designs of buildings may especially make the blackroofer's contribution the most predominant one.

The target benchmarks of Mischek's VOC reduction programme[4]) were set as follows:

Tab. 1: CHEM.RED. VOC reduction targets

Year	VOCs/app. [% 2000]
2000	100%
2001	75%
2002	50%
2003	40%
2004	30%
2005	20%

Besides improving worker's conditions and environmental performance, the wish for a substantial improvement in indoor quality was a major motivation for this decision. Indoor air quality is one of the key evaluation criteria of Mischek's Oekopass, a builiding certificate based on an independent control mechanism *(see separated contribution on Mischek's Oekopass included in this conference reader)*.

Project design
CHEM.RED. follows the following procedure:

1. Questionnaire
As Mischek produces housings as general entrepreneur, most of individual crafts are subject to bid to tenders. Incoming tenders are screened by financial and technical criteria. Those who are most likely to get the contract are then asked to submit a comprehensive list of all nonsolid chemical products to be used in the job[5]). For this context, a questionnaire sheet was created.

Sheets submitted are then checked for plausibility and the bidder asked to correct/ complete it if necessary.

2. Chemicals Check
For each of the products listed, the content of potentially harmful substances is then investigated mainly by checking Safety Data Sheets and Technical Fact Sheets.

If products with unacceptable contents resp. unacceptable amounts of harmful substances are identified, the availability of alternatives is investigated. This is done by a database query in the CHEM.RED. Database (see below) and/or by collecting additional information from producers.

3. Chemicals Substitution
If improved products meeting equal technical standards are available and affordable, the contractor is asked to substitute those products. If available, priority is given to products of the former supplier for economic reasons. Finally, the contractor is asked to sign the comprehensive list of chemicals as annex to his contract.

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[4]) VOCs not including solvents based on regenerative raw materials
[5]) i.e. products which are processed as liquids, solutions, mixtures, powder a.s.

4. Standard Upgrade

The results of these "learning by doing" investigations (standards of environmentally and toxicologically improved products) are subsequently introduced into bid wording, in order to progressively raise ecotox product standards.

CHEM.RED. Database

The information gathered during the CHEM.RED. process are continuously fed into the **CHEM.RED. Product Database**. Product information gathered here are the following *(Tab. 2)*:

Tab. 2: CHEM.RED. Database

- brand and product names
- craft(s) using the product (e.g. painting, flooring)
- type of product (e.g. linoleum adhesive)
- main chemical characteristics (e.g. "polyacrylate emulsion", "cementous mixture")
- risk labels as required by EU regulation (e.g. T toxic, F inflammable, N ecologically harmful etc.)
- dangerous substances contained (as listed in the Safety Data Sheet)
- special technical standards (e.g. flammability class, etc.)
- R- and S-phrases (e.g. R38 "Irritates skin.", R45 "May cause cancer")
- main product information by supplier (short description of purpose and main quality information, generally the introductory section of Product Manual)
- minimum and maximum application rates as (kg/m²)

and, most important :

- Ecotox Classification (s.b.)

Ecotox Classification

means the overall classification of products of a special type according to the main resp. the most important ecologically resp. toxicologically relevant criteria. Tab. ***3*** gives an example:

Tab. 3: CHEM.RED. Database Ecotox Criteria for flooring adhesives

VOCs content:

- solvent free
- low solvent
- solvent-containing
- high solvent

Aromatics content:

- aromatics free
- low aromatics
- aromatics-containing

Emission rate:

- ultra low emission
- low emission
- high emission

Softeners

- softener-free
- softener-containing

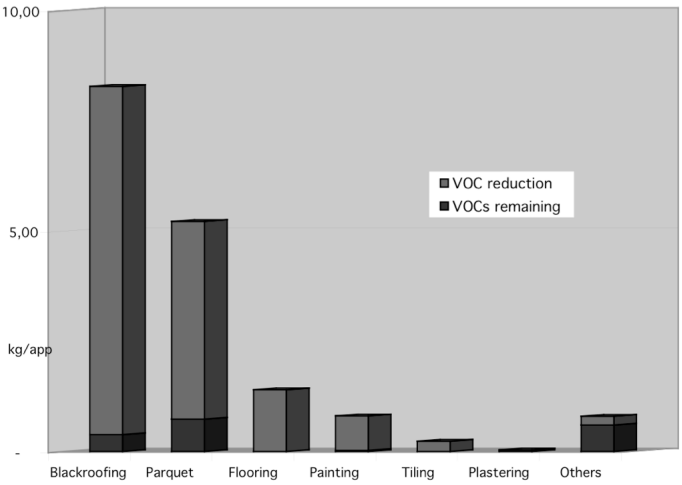
Formaldehyde (FAD):

- FAD-containing
- FAD free

By end of 2001, the following VOC reduction rates could be achieved:

Tab. 4/Fig. 2: VOC reduction by 2001

Craft	VOCs [kg/app.]	VOC reduction [kg/app.]	VOC reduction [%]
Blackroofing	8,28	7,90	95%
Parquet	5,22	4,49	86%
Flooring	1,40	1,40	100%
Painting	0,81	0,78	97%
Tiling	0,23	0,23	100%
Plastering	0,03	0,03	100%
Others	0,80	0,20	25%
TOTAL	**17**	**15**	**90%**



As can be seen clearly, the overall target of 75% for 2001 was exceeded by far. The two most VOC intensive crafts are blackroofer and parqueting. The lion's share of solvent reduction was achieved by substituting solvent based precoats of bitumen layers which contain large amounts of hydrocarbons including aromatics by water based bituminous emulsions. As most of the blackroofers' VOC potential was already subject for substitution, the main focus of the next year will lay on parqueting. Relatively slight modifications were necessary resp. possible for painting, as dispersion dyes in use for wall painting are already mostly solvent-free on the one hand and the possibilities to replace solvent-containing products in use (for metal coating, metal filling) still lack convincing alternatives in many cases. For floor covering and parquet, adhesives containing solvents were successfully substituted by solvent-free and ultra low emission products. A certain amount of solvents could not be replaced in the first run: Common emulsion based bituminous precoats can be applied only at temperatures exceeding 5°C, because they may otherwise freeze or the emulsion could possibly "break". This fact currently leads to the unsatisfactory situation, that emulsions cannot be applied during winter and, for reasons of indolence, many blackroofers tend to use solvent based precoats throughout the year. As part of this project, an improved product is currently being developed by one supplier in co-operation with Mischek: The upgraded product shall contain a certain amount of high molecular electrolytes, lowering thus the freezing point well below -5°C and allowing thus the application of VOC free precoats throughout the year.

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E3-Optimization: From Product Optimization to Sustainable Housing Concepts

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1. INTRODUCTION

Mischek is a Viennese company developing and building residential housing projects with approx. 1 000 flats every year. Mischek has its own production plant for prefabricated concrete components (annual production volume: 95 000 tons). PREPARE projects have been both ecologically and economically successful since 1995. A wide range of innovations and improvements in the areas of energy, waste, water, transportation, material development have been implemented resulting in ecologic and economic improvements of the production process. [1]

But these environmental and economic efficiency (E3) implementation measures are just one part of E3 building life cycle - from development and construction till the use and after use phase - have to be taken into consideration when the residential building is developed. Among them are future work environments, demographic changes, changes in society, technology issues, environmental issues, indoor air quality, architecture, new service concepts for tenants, mobility, energy, supply and disposal.

2. RESULTS AND DISCUSSION

This E3 approach has been the basic planning principle for the overall design of many innovative housing projects that have been developed and realized by Mischek in the past years. Mischek uses a two-way approach:

General tools which secure quality of planning and building.

- Most important is the building certificate “Mischek Oekopass”, which was developed together with the IBO – Austrian Institute for Healthy and Ecological Buildings (www.ibo.at). The Mischek Oekopass focuses on eight criteria to keep the building certificate easy understandable and meaningful at the same time. Five key criteria are defined to evaluate the inhabitant comfort: indoor air quality, comfort in summer and winter, acoustic properties, electromagnetic properties and sunlight and brightness. In addition the ecological properties of the building (construction and materials) are judged as well as energy and water efficiency measures. All these quality parameters are evaluated by the IBO with measurements or calculations.
- Good indoor air quality is secured by a sophisticated quality management system with the responsible craftsmen leading to dramatic reductions in organic solvent use.
- Mischek has commissioned a garden plot concept at “Arche Noah” (www.arche-noah.at), a society which works to protect biodiversity by using the appropriate plant species and garden design and materials. Of course this concept leads to attractive garden plots, where tenants feel comfortable.
- High standards of water and energy efficiency for all apartment buildings as well as rail-based transportation concept for prefabricated building components.

Project related efforts to adjust the ecological and social concept are f. e. involvement of the future tenants during certain parts of the planning process like design, use and management of community rooms or development of house rules. In one project, the car-free model estate (250 flats), tenants decided how to spend the saved building costs (no garages as there are no cars) for other community purposes.

Some current projects:

- The Mischek Tower, a 35-floor skyscraper (505 flats), where a modern intranet system is used to build an IT-based community. Meanwhile this communication tool has been used successfully in several other apartment buildings in Vienna.
- Mischek is building two skyscraper (total 250 flats) as part of the urban development project "Wienerbergcity" (www.wienerbergcity.at) . Three skyscrapers are linked on the 8th floor with a "skyloop", which leads to the leisure center of the Wienerbergcity.



Figure 1 Wienerbergcity skyscrapers connected with a skyloop to the Leisure Center

- A tenants participation project (50 flats) secures maximum involvement of all future inhabitants based on a flexible architectural concept with high environmental standards. As a building material a mix of wood and concrete prefab components will be used.

- Vienna's 1st PVC-free apartment building (32 flats) is currently being build. While the use of PVC-free window frames, pipes and floorings is standard at Mischek, the PVC-free electrical equipment proved to be the most challenging for the electrician. This project proves the possibility of phasing out the environmentally hazardous PVC (poly vinyl chloride) plastic from the construction industry. Additional costs for the PVC-free electrical installations were relatively low, approx. € 900 / flat.



Figure 2 Vienna's first PVC-free apartment building

3. OUTLOOK

Using its newly developed building certificate Mischek Oekopass as a planning, quality management and marketing tool gives Mischek the opportunity to further improve its work and the comfort of the apartment it develops.

With other innovative concepts like the indoor air quality program, the rail based logistics concept and the "Arche Noah" garden concept Mischek feels well positioned for further challenges.

Combined with project specific social-ecological development adaptations like described above Mischek has realized a number of guiding projects in the past years.

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A method for the experimental comparison of two heating and cooling radiant systems in different climatic conditions

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1. INTRODUCTION

In the framework of the Italian National Interest Research Project (PRIN 2000), an experimental campaign for the investigation of the energy performances of different radiant heating/cooling systems has been conducted at the Politecnico di Milano test facility.
Two rooms have been equipped with radiant ceiling, floors and walls. Different configurations have been considered for heating purposes (only ceiling, only walls, only floor, walls + floor, floor + ceiling) with the aim of assessing the best efficiency in terms of energy consumption for given comfort conditions. Two of these configurations have been tested, each one for several days and, during such periods, measurements were carried out for energy consumption of the plant (heat pump), indoor air temperature, mean radiant temperature, relative humidity and air velocity together with outdoor temperature, air velocity and solar radiation.
In order to define a series of reference data for the energy consumption, a conventional heating system demand has been calculated for each test period. Such calculations have been performed by means of a DOE-2 model that has been previously validated. A comparison among the performances of different system configurations has been done on the basis of a global efficiency based on reference consumption data.
In the next steps of the research program, also different control and regulation strategies will be investigated in order to assess the importance of PMV or operative temperature based controls versus air temperature ones.

2. EXPERIMENTAL SET-UP

The research was carried out in an experimental building constructed on the outskirts of Milan in the context of a convention between the ESEM institution and the BEST department of the Politecnico di Milano. Two rooms of the building (test rooms) were equipped, with three different radiant surfaces: floors, walls and ceilings. Each system could be utilised either for heating or for cooling purpose. A water to water heat pump connected to an external underground heat exchanger generates hot and cold water. Primary and secondary loops are coupled through a heat exchanger. The delivery temperature in the secondary circuit is

regulated at a fixed point by a three-way valve. Figure 1 shows the scheme adopted for the secondary loop connected to radiant walls and ceiling. Figure 2 reports the scheme of the whole plant.

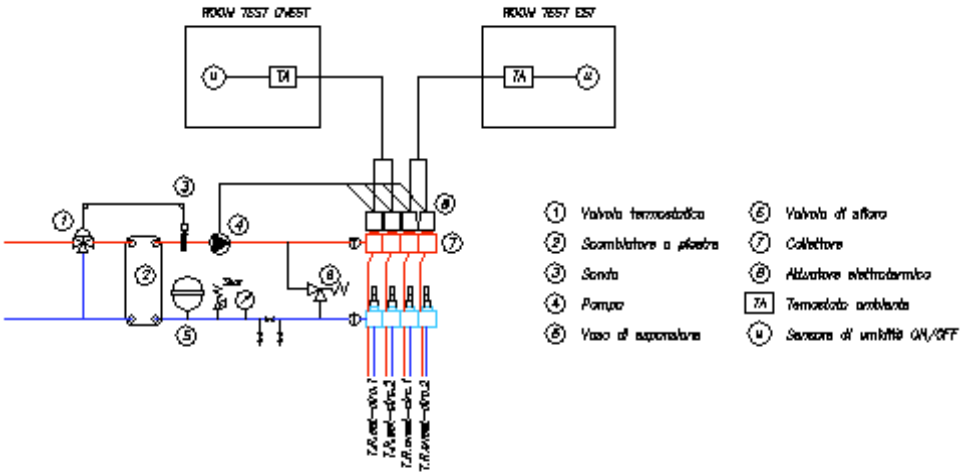

Figure 1 Secondary loop for radiant walls and ceilings

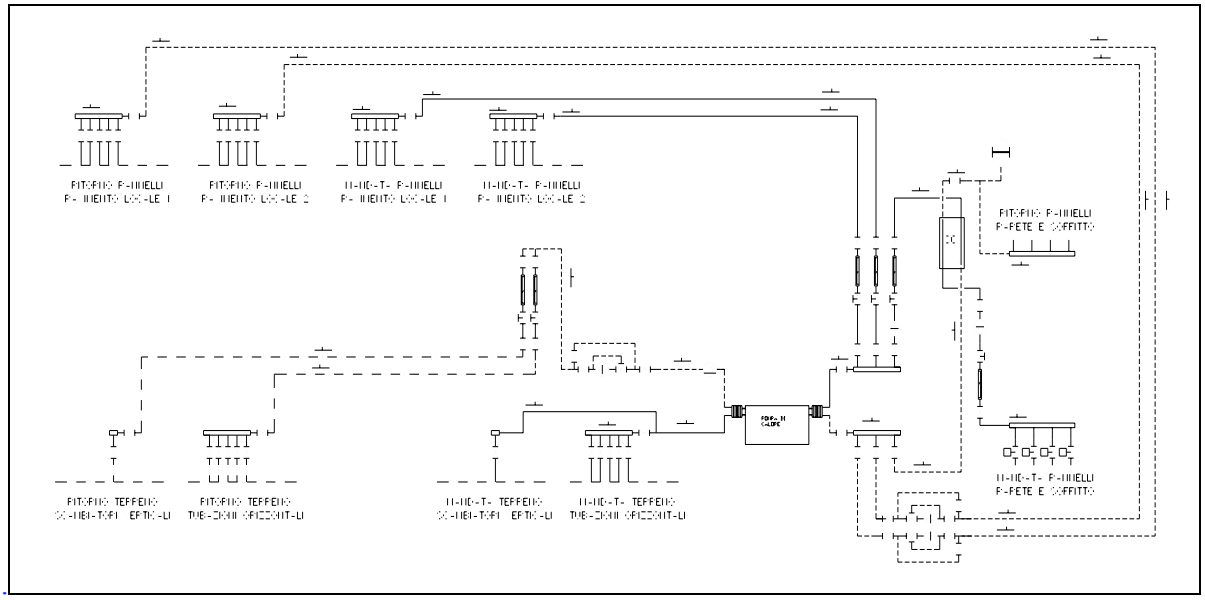

Figure 2 General scheme of the building plants

The two test rooms are adjacent and have the same volume, the same exposure of the windowed facade and the same window area. The cavity wall separating the two rooms is to be considered adiabatic. The radiant ceiling is mounted in the west test-room while the radiant walls are in the east test- room (figure 3). Both systems have net exchange surfaces of 12 m^2. Moreover, to obtain the same net volume for both rooms, a plasterboard false ceiling of the same dimensions as the radiant panels of the west room has been installed in the eastward facing one. The roof panels are made up of multiple panels composed of a plasterboard plate and an insulating layer (Styrofoam) integrated with minute pipes for the circulation of water. The minute pipes are made of polypropylene with a diameter of 3.35 mm and thickness of 0.5

mm and are placed with a step of 15 mm. The indicative yields with at 10°C temperature difference are 65 W/m^2 in the cooling mode and 85 W/m^2 in the heating one.

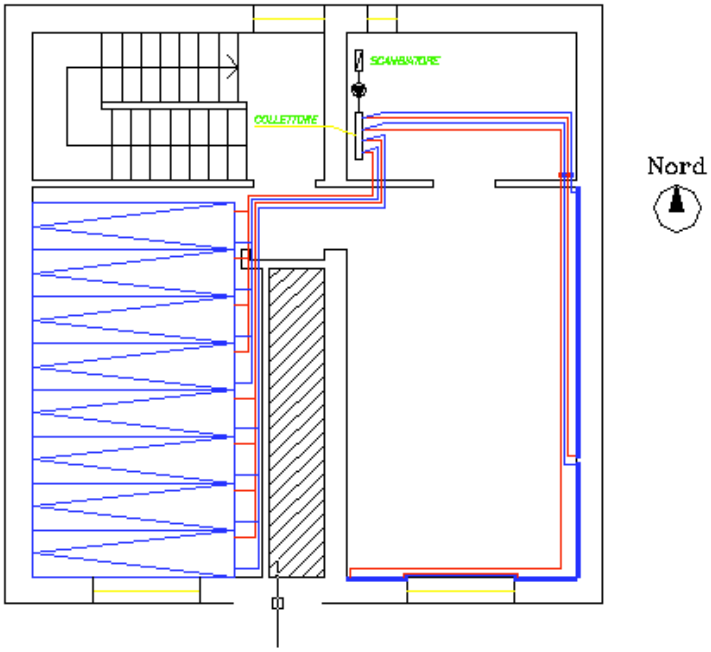

Figure 3 Panels displacement

The wall panels are made up of pre-assembled circuits adjoined by means of wall anchors. Such circuits record a 75 cm width and 180 cm height and are made of a horizontal delivery collector and a collection one (diameter 20 mm and thickness 2 mm) and of 50 vertical circuits realised with minute pipes as the ones previously described. The circuits have been later covered with a mortar plaster 2 cm thick and reinforced with a glass fibre net.

The data are collected and recorded by a system composed by two mainframes HP 1326B where 7 data collecting slots HP E1345A (16-Channel Relay Multiplexer Module) have been installed. The software controlling the whole data collecting and recording system is the HP VEE (ver.5)
This system records the average values of the following parameters at hourly intervals:

- external air temperature and humidity,
- wind velocity and direction,
- global solar radiation on horizontal surfaces,
- air temperature and humidity, mean radiant temperature and surface temperature of the floor and walls in each internal zone,
- temperature of the ground at depths of 0.5 m, 1 m, 1.5 m and 2 m away from the coils and at depths of 1.5 m and 2 m close to the coils.

The weather station is composed by a thermoigrometer, recording external humidity and temperature, by an anemometer for the wind speed and by a global radiometer recording the global solar radiation on a horizontal plane

3. TEST DESIGN AND METHOD OF COMPARISON OF THE RESULTS

As can be seen in the general scheme of the plant, each of the two rooms represents a thermal zone. The system installed, in its basic configuration, envisages a zone to zone thermostatic regulation by means of a motorised valve installed in the delivery collector cut off.

Provided that the closure of the motorised valve in one zone could cause an increase of the flow rate in the other part of the circuits it is has been stated to make the rooms to run not at the same time. In this was way the data acquired for the two rooms are referred to two different time periods.
In order to compare the performances of the two systems analysing two set of data referred to two different time periods and thus weather conditions, a sort of reference performance has been assessed with the use of a thermal model of the building set up for the DOE-2 simulation programme. The building thermal model has been calibrated with a comparison among the results of a DOE-2 run referred to a specific time during which the outdoor climatic data and the internal temperatures of the rooms have been measured by the data-logger.
Weather file of DOE-2 has been created starting by the values recorded during the experimental campaigns. In the model, the building has been subdivided in 5 thermal zones (two test rooms and three adjacent spaces), and all the physical properties of the materials have been detected.
For a calibration purpose, both in the test period and in the simulation runs the test rooms were neither heated nor cooled. In the following graph the series of free-floating temperatures obtained as output of the DOE-2 run and measured during previous test are compared. Figure 4 shows the good calibration obtained after the tuning of the model.

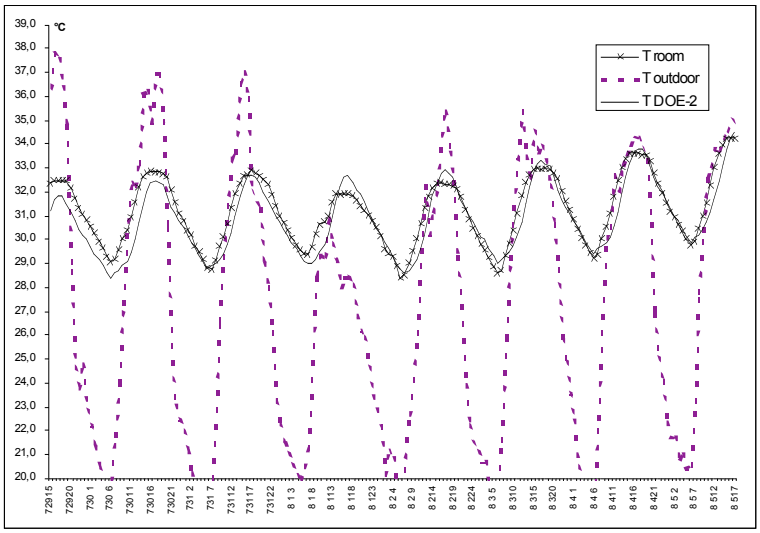

Figure 4 Time series of Outdoor, Room and DOE-2 output temperatures

During the test of the heating/cooling systems the metered energy demands (net output of the heat pump) have been compared with the correspondent reference values, that are the theoretical heat demands calculated by the DOE-2.
A sort of gross efficiency has been defined as follows:

R/M = reference energy demand/measured energy demand

The higher is the value of R/M the lower is the consumption of the system according to the theoretical demand.

4. RESULTS OBTAINED

The two systems have been monitored in two different time period during March 2002. When one system has been turned on the other one was off. In addition to the ambient parameters

measured in both the rooms the following parameters have been measured for the heating plant:

- supply and return temperatures of the water (leaving/entering the heat pump hot coil)
- water flow rate

The set point temperature for the supply water was 45°C, in order to obtain panels surface temperatures of about 30°C. The flow rate of the fluid in the heat pump has been set at 300 l/h, the same as that of the fluid in the underground exchanger. On the other hand, the flow rate in the two rooms where experiments are carried varies from 100 to 150 l/h.
The following graphs shows the comparison among the measured and the reference heat demands referred to the two experimental campaigns. The first one (figure 5) is referred to the radiant wall system; the second one (figure 6) refers to the ceiling.

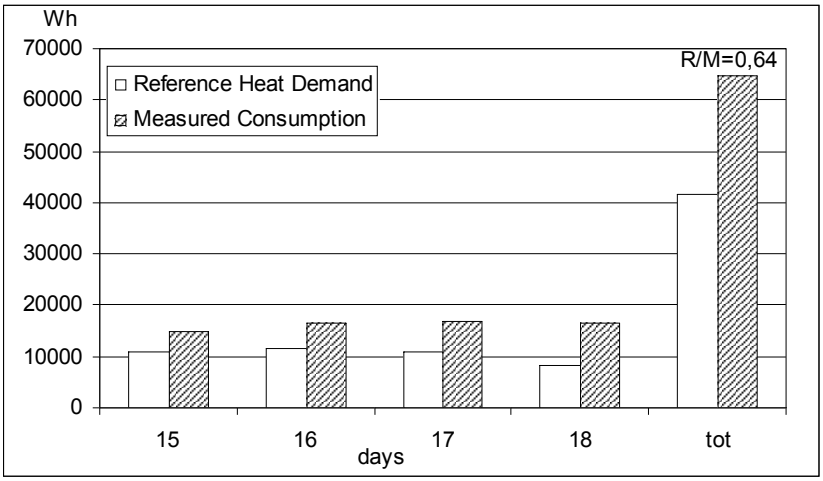

Figure 5 Comparison among reference and measured heat demand for radiant walls

It can be noted that the performances of the radiant ceiling appear significantly higher with respect to the other system. The main reasons lays on the lower heat losses that the second systems allows being not directly coupled with the external building envelope.

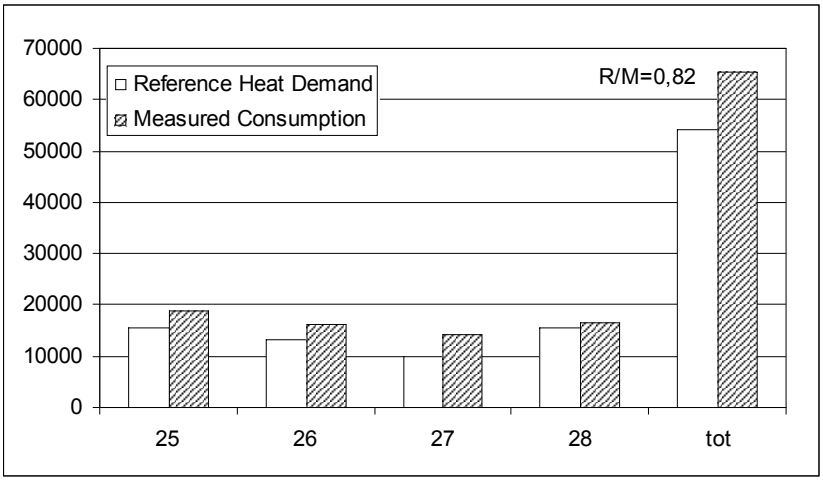

Figure 6 Comparison among reference and measured heat demand for radiant ceiling

4. CONCLUSIONS

The paper presents the experimental set-up carried out in a test building equipped with different room heating/cooling radiant systems. In addition a method for the analysis and the comparison of results obtained during runs conduced in different climatic conditions is described.

Anyhow, it must be stressed that the results presented are only a first essay of a wider analysis that will be conducted in the next months in the test building. The aim is to point out the relevance of other performance parameters such as the ones describing the quality of the comfort provided by the systems, that can probably disagree with the energy approach here presented. For this reason the plant is going to be equipped with hardware and software able to provide more sophisticated control strategies than the thermostatic one. These strategies will be based on comfort parameters such as operating temperatures or PMV. The energy saving potential of this approach can be significant.

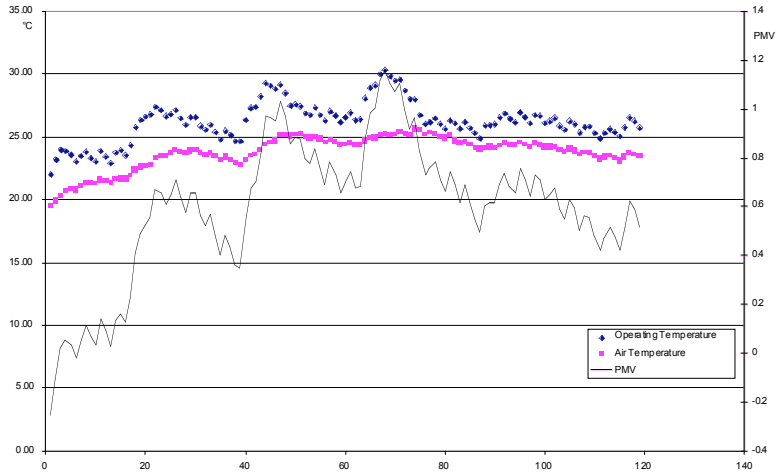

Figure 7 PMV, operating temperature and air temperature for the west room

For instance, if we look at the PMV time series calculated for the ceiling system during the test (fig. 7), it can be noted that if the allowable PMV is restricted in a narrower range the system could be turned off for many hours providing a cut-off of the energy consumption and a better comfort-side performance.

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Simulation Model of Air Handling Units for Solar-Assisted Building Climatization

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1. INTRODUCTION

The integration of solar energy systems with a building for air-conditioning is a very attractive application for building climatization. The Desiccant Evaporative Cooling (DEC) Systems driven by solar energy are interesting type since the low temperature heat (50-80°C) required for regeneration can be obtained by integrating it with a low grade energy source such as waste heat or solar heat or co-generator (Lof et al., 1985, Waugaman et al., 1993, Lof, 1992). By eliminating the need for traditional refrigerants and reducing the consumption of fossil fuel and associated emission of CO_2, such alternative systems can be beneficial to the environment.

Desiccant cooling is basically an open cooling cycle consisting of a dehumidifier, sensible heat exchanger and evaporative water spray cooler (Henning el al., 2001). In a DEC system, the potential for the application of evaporative cooling is increased by means of air dehumidification.

In the present communication, a steady state model has been presented for performance simulation of a air handling treatment plant integrated with solar energy system. Model utilizes a new numerical algorithm (Beccali et al., 2002) for performance calculations of rotary wheel air dehumidifier. Other unitary treatments are modelled through typical algorithms based on simple psychometric correlations for calculating relative humidity and temperature of regeneration air streams. The model has also provision to integrate the air handling unit with any kind of thermal energy source to drive the air dehumidifier e.g. cogenerator, hybrid photovoltaic-thermal solar energy systems etc. The simulation results are presented for a desiccant based air handling treatment unit for a typical office building at Turin in Italy. The study is carried out to show the use of desiccant technology for building climatization with regard to the potential of the integration of solar thermal energy. The developed simulation model is a useful tool for design optimisation of air handling units for solar assisted building climatization.

2. OPERATING PRINCIPAL OF A TYPICAL SOLAR POWERED DEC SYSTEM

A schematics of basic desiccant cooling cycle with a desiccant wheel dehumidifier is shown in Figure 1. The psychometric state of air during various processes has been shown in Figure

2. Ambient air is dehumidified in the desiccant wheel and becomes dry and warm (**1→2**). The air cools down in counter flow to the building outlet air (**2→3**); in general a rotary heat-exchanger is used for this purpose.

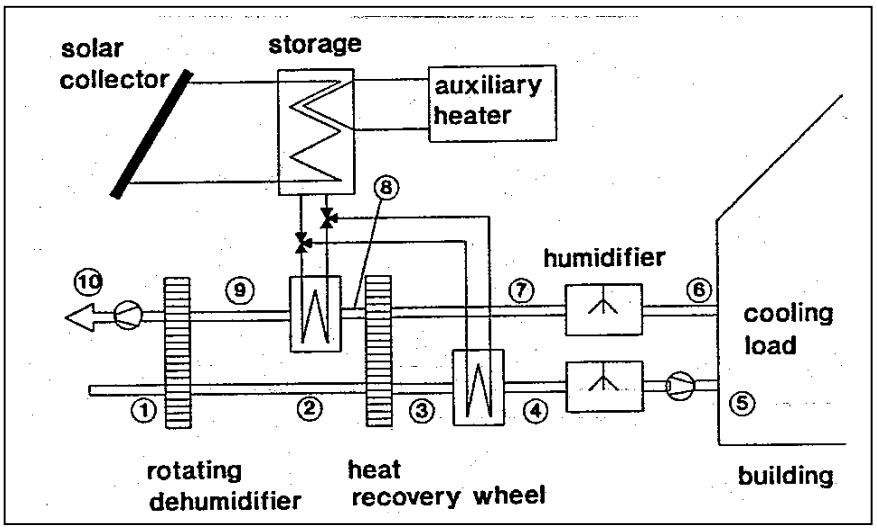

Figure 1 Schematics of a solar assisted DEC system.

The inlet air heat-exchanger (**3→4**) is not active in the case of cooling. The air is further cooled down with a direct evaporative cooler and its humidity increases (**4→5**). The internal heat and water vapour loads in the building lead to an increase in both, temperature and humidity (**5→6**). The outlet air is again cooled down by evaporative cooling (**6→7**) and heats up in counter flow to the inlet air (**7→8**), The air heats up to the regeneration temperature in the regeneration heat-exchanger (**8→9**). In this step, the integration of regeneration heat-exchanger with a solar energy system becomes effective. Regeneration air is used for the extraction of absorbed water from the desiccant (**9→10**). The desiccant cooling systems allow the use of solar thermal energy for both cooling and heating purposes.

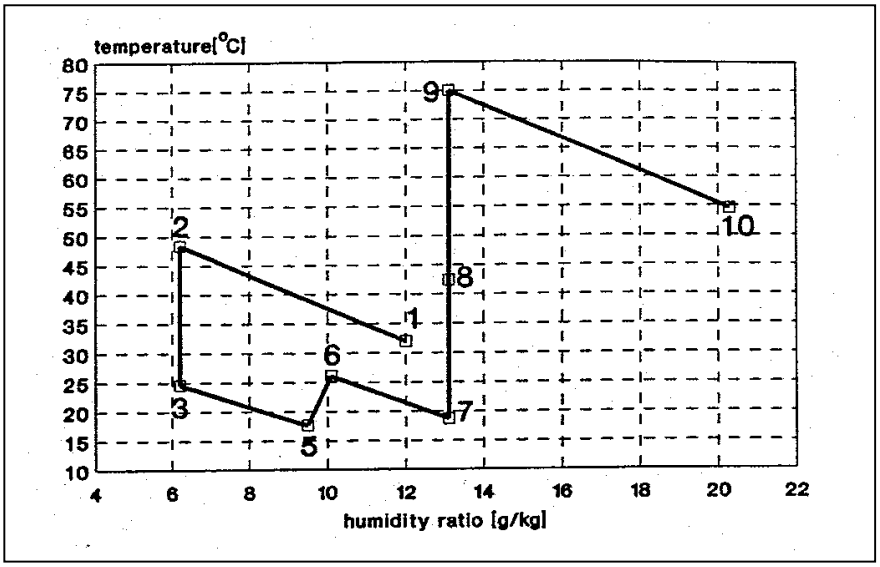

Figure 2 T-X diagram of humid air showing the air states of a desiccant cooling cycle.

3. MODEL CALCULATIONS

A steady state model has been developed to simulate the performance of DEC plant integrated with a solar energy thermal system and cogenerator. It has been implemented in a MS Excel worksheet (figure 3). Some macro-routines allows for the convergence of calculation and for the data input-output management. The model utilizes a new numerical algorithm for performance calculations of rotary wheel air dehumidifier (Beccali et al., 2002). Other unitary treatments are modelled through typical algorithms based on simple psychometric correlations for calculating humidity and temperature of regeneration air streams. The modelled treatments are: air mixing, sensible heating/cooling, sensible heat exchange, isoenthalpic humidification.

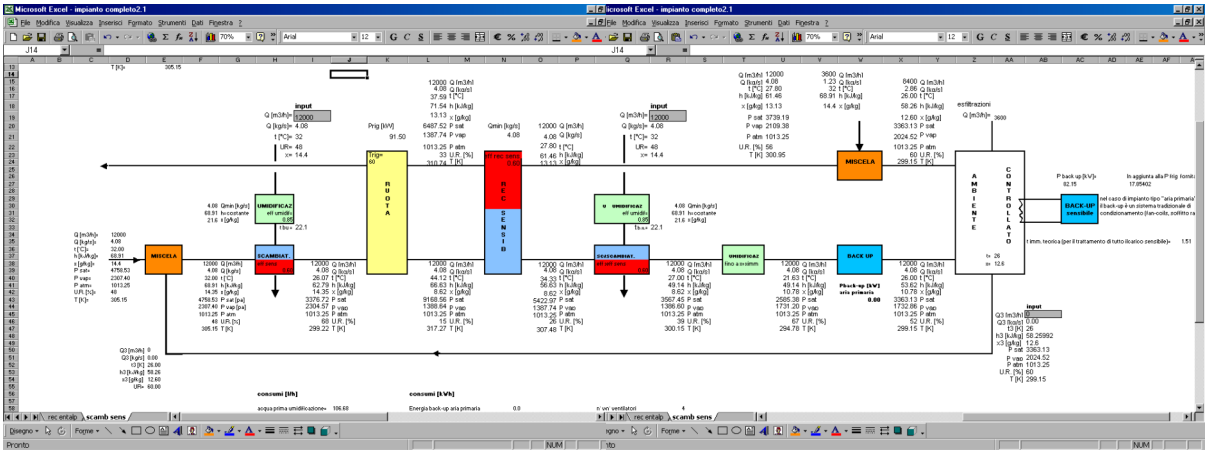

Figure 3 A screen-shot of the Excel model.

The schematics of the plant described in Figure 1 shows the air treatment with a back-up in the regeneration side. The model also takes care of the cooling back-up together the load (latent and sensible) in case the plant is not able to meet the requirements.

To appreciate the developed model, numerical calculations have been carried out for performance simulation of the Kitchen of an office building where a restaurant for 800 people is present. The building is located in Turin, Italy and the simulation have been carried out for summer months (June to September). The values of various parameters used in the numerical simulation has been described in Table 1.

Table 1 Parameters for numerical simulation.

Parameter	Value
Building Return air temperature	26 °C
Building Return air Relative humidity	60% (Absolute humidity = 12.6 g/Kg)
Inlet air flow	14750 m^3/h
Return air flow	0 m^3/h
Exhaust Air Flow (To heat-exchanger)	10000 m^3/h
Latent heat per person	62 W/p
Number of persons	8
Latent load (Kitchen Appliances)	18,5 kW
Desiccant Wheel Regeneration temperature	80°C, 60 °C
Desiccant Wheel Regeneration Power	90 kW
Heat recovery efficiency	65%
PV/T Collector Area	160 m^2
Tilt angle	60°

Azimuth	South

The thermal performance simulation of office building has been carried out using DOE 2.1 E simulation software and the output file from DOE has been used as the input for our simulation model. The weather file utilised both by DOE-2 and the Excel model has been generated with METEONORM V4.0 Software. It has been assumed that the DEC plant is integrated with a cogenerator and solar hybrid PV/Thermal system. Also the solar system has been simulated through an algorithm implemented as an Excel macro.

4. RESULTS AND DISCUSSION

The simulations have been carried out for the Kitchen of the office building at Turin corresponding the desiccant cooling plant which utilizes a silica gel rotary desiccant wheel. The climatic parameters (daily horizontal global solar irradiance and ambient temperature) corresponding to different months of the year for Turin climate has been shown in Figure 4.

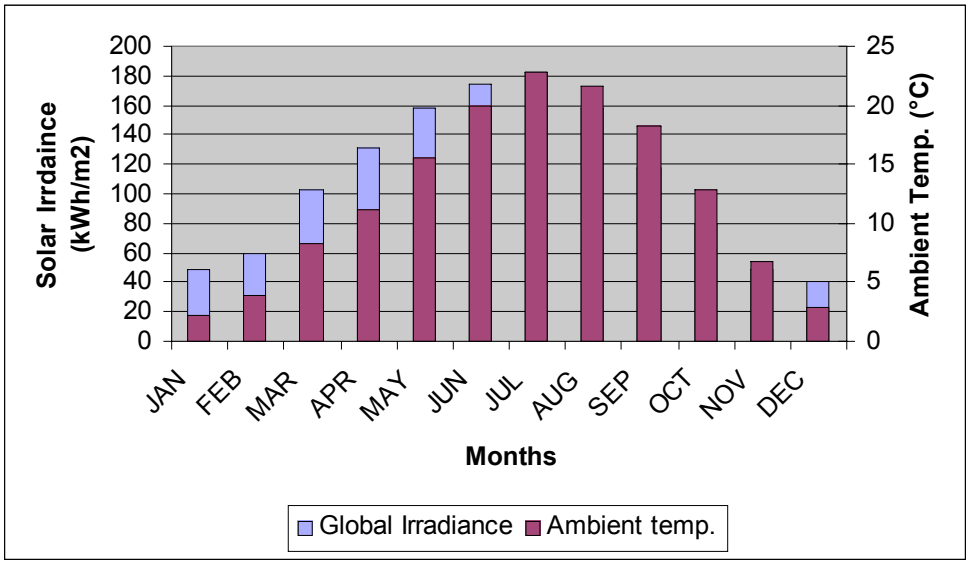

Figure 4 Daily horizontal global solar irradiance and ambient temperature for the climate of Turin, Italy.

The results of the simulation of desiccant plant corresponding to regeneration temperature equal to 80 °C for summer period are shown in Figures. 5-8.

Figure 5 shows, for one week, the hourly calculation of the amount of sensible load handling provided by the DEC system without any back-up and the one given by the latter.

In a seasonal basis the contribution of the back-up is of about the 40% (see fig.6). The good performances of DEC in the dehumidification task resulted in 100% of the latent heat handled without any back-up in the cold coil.

In the same time it can be noted that the solar system is able to provide about the 60% of the heat required for the regeneration of the Desiccant Wheel (figure 8). A surplus of heat generated by the solar system is due to the load-supply mismatch. Figure 7 shows that in some days there is no need of back-up.

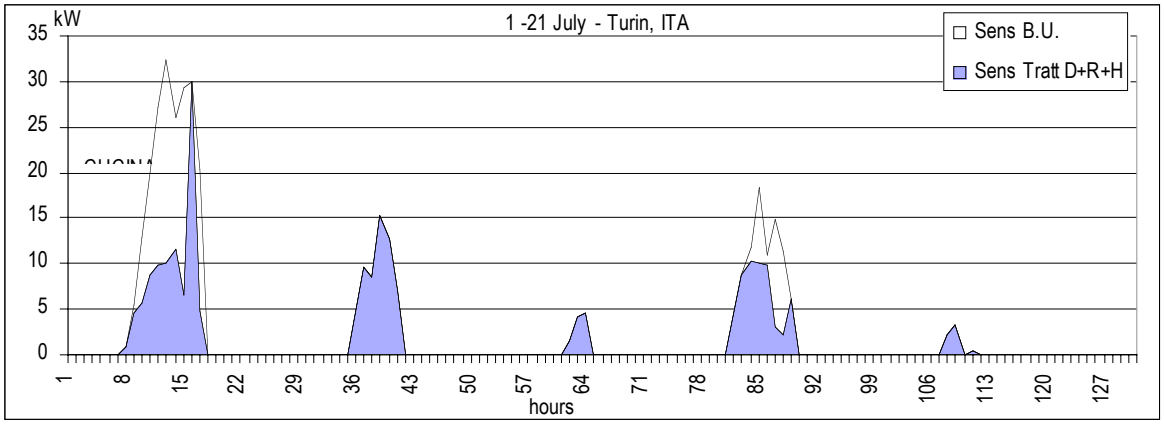

Figure 5. Hourly calculations for sensible load.

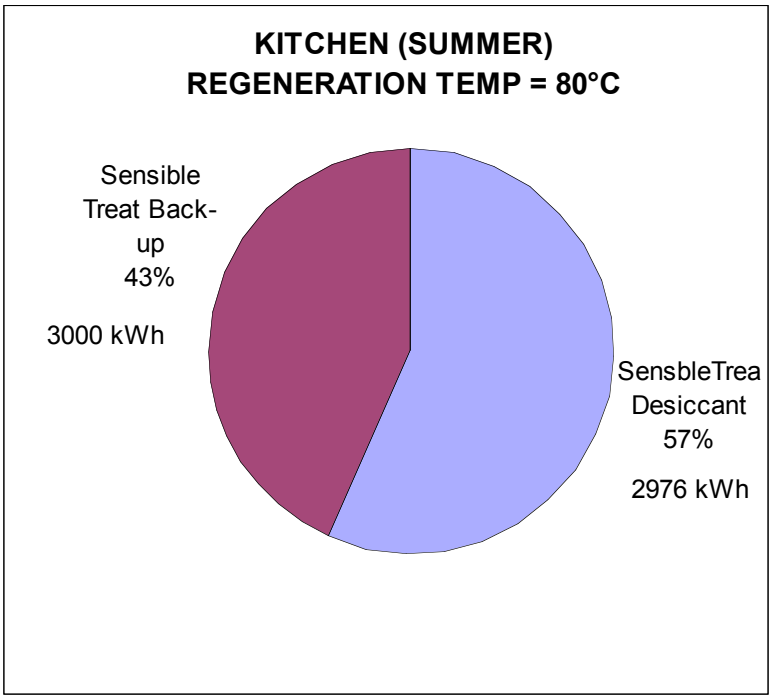

Figure 6 Seasonal results for sensible load.

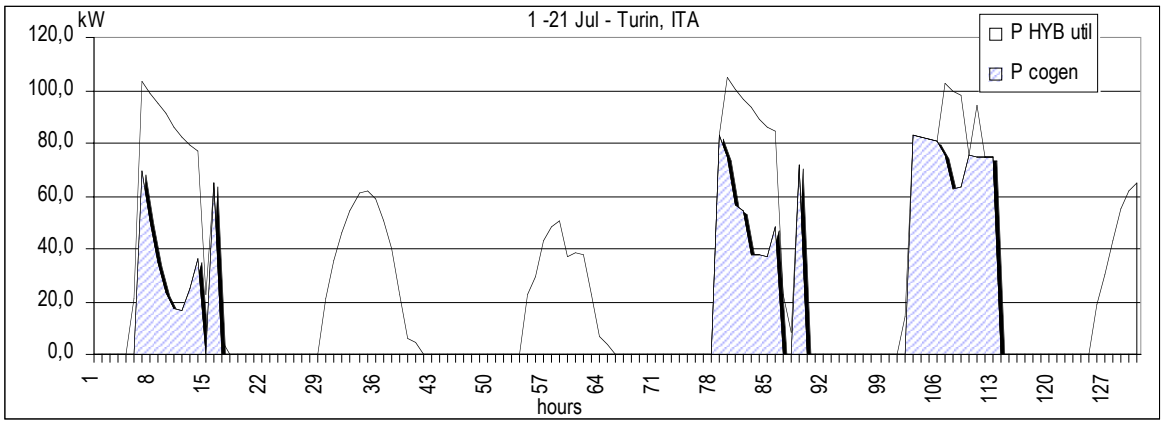

Figure 7 Hourly calculations for DEC regeneration power

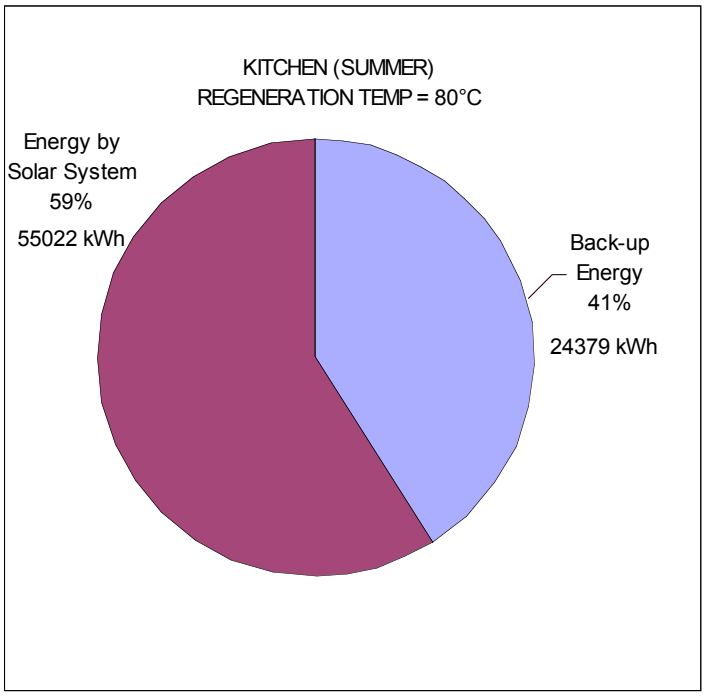

Figure 8. Seasonal results for DEC regeneration power

5. CONCLUSION

A steady state model has been developed to simulate the performance of DEC plant integrated with a solar energy thermal system and cogenerator. The utility of the model has been seen by carrying out simulation for a solar assisted desiccant plant in a office building of Turin, Italy. The simulation model allows the user to vary a range of design parameters and to calculate their effect on the system performance. The model can be used as design tool for solar assisted desiccant plant.

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Integration of decentralised sanitationsystems into a built environment

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1. INTRODUCTION

Waste is an important element in our world. It is not the subject people are engaged with. All the same wastewater streams are from such size that we cannot ignore them and good structures are needed to deal with them. These structures seize space. This article goes into wastewater and the role it plays in the built environment.

2. CENTRAL SANITATION SYSTEMS

In the Netherlands one person uses on average 135 litres water of drinking water quality (NIPO 1995). Only 3 litres of this high quality water is really used for drinking and cooking. This one person produces 120,7 litres wastewater per day (Heide 1996). The largest part of this wastewater is carried away by a sewer; 97,5 % of the households in the Netherlands are connected to the sewer. The produced domestic wastewater is treated in central urban sanitation systems. In the Netherlands are 424 public water treatment systems which treat 5 million m3 wastewater. These systems treat 21 million i.e. (inhabitant –equivalents= amount of waste produced by one person). The wastewater exists of rainwater and domestic wastewater. The current municipal water- and wastewater management systems that are developed over the years in industrialised countries are characterised by:

- Acquisition of fresh water from groundwater, protected water reservoirs
- Controlled purification of raw water and safe distribution of high quality water
- Collection of sewage and rainwater by means of sewers
- Transport of the collected wastewater out of the urban areas
- Advanced treatment of waste- and stormwater
- Control of the treated water before discharge into natural surface water bodies
- Treatment and utilisation or controlled disposal of the waste sludge

This method is commonly known as central water and wastewater management. Advantages of the system are that the system can be managed reliably and efficient and the costs are low because of the large scale. The key-word with central treatment is control: pathogen organisms can spread diseases when they are not removed efficiently from the wastewater. At the same time the regulation for draining is important. Exceed of these limits can cause corrosion of surface water bodies. From a users point of view the current central systems functions well: it hygienic and reliable. There is no reason to change the system. Despite all the advantages some disadvantages occur which cannot be ignored, especially not in the light of sustainable urban wastewater management where efficient use and reuse play an important role.

The advantage of scale for the costs of a large treatment system disappears when the costs of distribution and collection are taken into account. These are many times higher then the costs for the treatment system itself. In the Netherlands lie over 80.000 km of sewer pipes in the ground. The maintenance and construction is difficult and costs a lot of money.

Sewer pipes often leak and this causes pollution of the ground and groundwater because of infiltration. On the other hand infiltration of wastewater in the groundwater in the sewer pipes will put an extra load to the system. On average six times a year the capacity of the pipes is not big enough to deal with the peak load. This causes pollution in the surface water bodies (eutrophication) which can be a problem with harvesting drinking water.

Wastewater contains valuable nutrients. These originate mainly from domestic wastewater. This can be subdivided in two categories: Black water (toilet water) and grey water (the remaining wastewater). In the table below the composition of the most important parts of domestic wastewater are shown. Black water contains the largest part of the nutrients. Eye-catching is the role urine plays: it contains the largest part of the nutrients (N,P,K) while the volume is small.

Yearly/person	Grey water	Urine	Faeces	Black water
N 4-5 kg	3%	87%	10%	97%
P 0,75 kg	10%	50%	40%	90%
K 1,8 kg	34%	54%	12%	66%
COD 30 kg	41%	12%	47%	59%

Table 1. Composition Domestic Wastewater (Henze 2001)

Because domestic wastewater and rainwater flow together into the same systems. This leads to a complete mix of pollution that varies all the time in composition and concentration. This makes it more difficult to remove all the pollutants effectively. The sludge that remains after treatment contains heavy metals and therefore it cannot be used as fertiliser. The present nutrient cannot be regained and are lost when the sludge is burnt. An other aspect that evokes questions is the social awareness of consumers with the system. Consumers are not irresponsible behaviour using the sanitation system.

From the point of view of wastewater management a research for other sanitation systems does not result from hygienic considerations. But the unclosed nutrient loop, the large consumption of high-quality water and the extensive sewer system make it worthwhile to investigate alternative forms of sanitation. Alternatives which comply with the closed nutrient cycle with reuse of energy, nutrients and a sustainable wastewater.

3. DECENTRAL SANITATION SYSTEMS

On other method of approach of purification of wastewater are the Decentralised Sanitation and Reuse technologies (DESAR). Many of these systems are yet brought into use all over the world. Especially in areas where no sewer is available. Except for remote areas, DESAR-systems can be the answer to sustainability problems with central sanitation concepts in the Netherlands. Many developments are going on at the field of DESAR. The concepts for DESAR have the following in common:

- Integration of water, wastewater and domestic waste management systems
- Separated collection and treatment of different categories waste flows
- Regaining of valuable parts for further and mostly direct use (water, compost, biogas and fertiliser)

Examples of DESAR-systems are compost toilets, reed beds and anaerobic filters. Because DESAR-systems are put into practice on a small scale, no or very few sewer pipes are needed. This causes a saving on costs and material. The waste has to be transported on a shorter distance and therefore no or less water is needed for transport. On average 1/3 of the total water use can be saved. (1/3 of the water in a household is used for toilet flush).

Because of the partition all of the waste streams can be treated particularly and nutrients can be regained and reused. The nutrient cycle can be closed. Although decentral sanitation seems to be an answer to a lot of the problems with central concepts there are some points of attention that have to be developed to make application on a large scale possible:

- In household waste are non-biodegradable parts present that stay in the cycle
- Waste has a variable composition which can be a hindrance for the purification process
- The sanitation process has to be developed more
- Adaptation of legislation is needed
- Little is known about the presence of endocrines and hormones

In spite of these bottlenecks decentral sanitation stays an serious option to replace central techniques in the future. Except for sanitation technical points of attention means a shift form central to decentral sanitation also that the systems come closer or even in built environment. This effects building structures, buildings and users. To illustrate a few of these effects a design cases will be elucidated. The case is the application of a green algae system in a house.

4. DESIGN-CASE: A GREEN ALGAE SYSTEM

Green algae can purify wastewater. Usually this takes place in a pond. For growing food is supplied in the form of wastewater. The purification process is based on the co-operation between micro-algae and bacteria. The production of micro-algae in a mass-culture depends on:

- Light-climate
- Temperature
- Availability of food

The reduction of organic matter is 95 % and pathogens 99,9% (ref. NOVEM 1993).
The green algae system has been put into practice for animal manure growing algae in large ponds but not for household water on a small scale. The following concerns the review of a design case. This does not preclude we can learn from the integration aspects when the system is applied. The algae system is designed to treat black water of a four-person household. The grey water as well as the kitchen waste is treated separately depending on the specific situation. The

algae system consists of the following elements: a vacuum toilet system, a septic tank (pre-treatment), an algae tank and a harvest- and storage unit.
In the scheme below the process is shown:

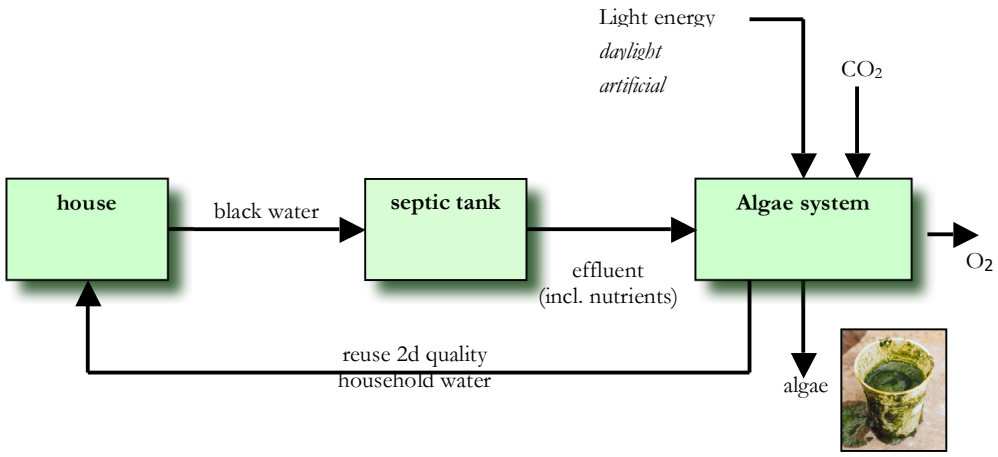

Figure 1 Scheme green algae sanitation system

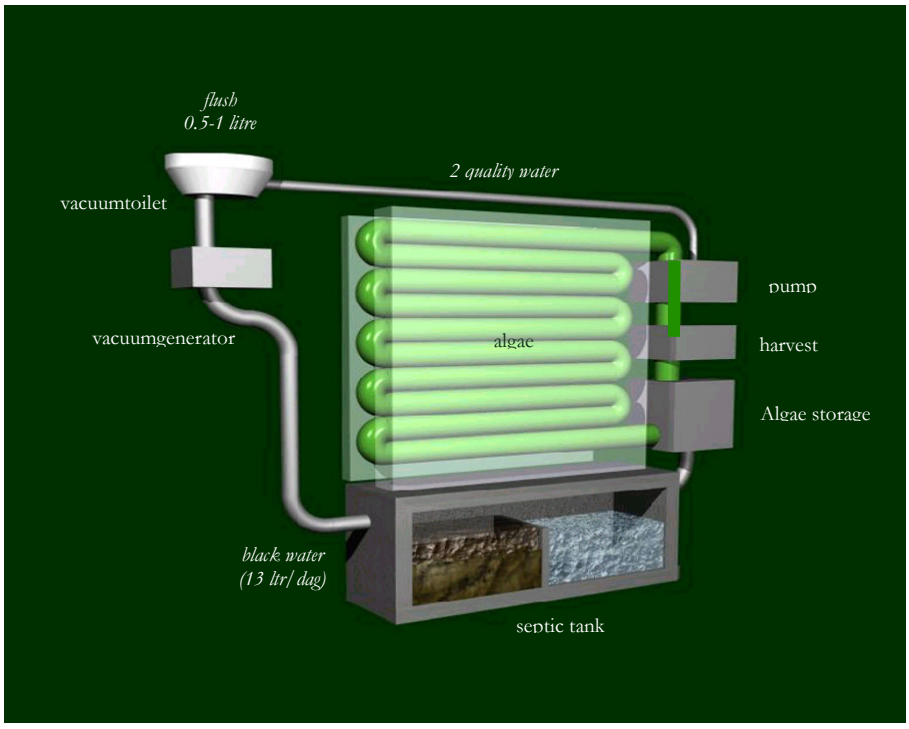

Figure 2: Elements of algae system

Location of the system
The growing process takes places by photosynthesis. A minimum amount of light is needed to grow algae. This limits the sites where the system can be placed in the house. Orientation to the South-East produces the highest light proceeds. If the algae are overexposed the growing process will be damaged. This can happen in the summer season. In this time of the year the sun stands high on the horizon. When the system is placed in a vertical position the light incidence is less

intensive in summer and more intensive in seasons when the light is needed. In the winter months when sunlight is less intensive and only available for a shorter period per day additional light is needed. Artificial light from the house can be used. Implementing the inner side of the algae element in glass makes this possible. Jón Kristinsson has made a sketch in which is shown that the algae element is placed in the breastwork of the façade (Fig 3). The outer side is covered with translucent insulation to let in daylight and at the same time insulate the house and system.

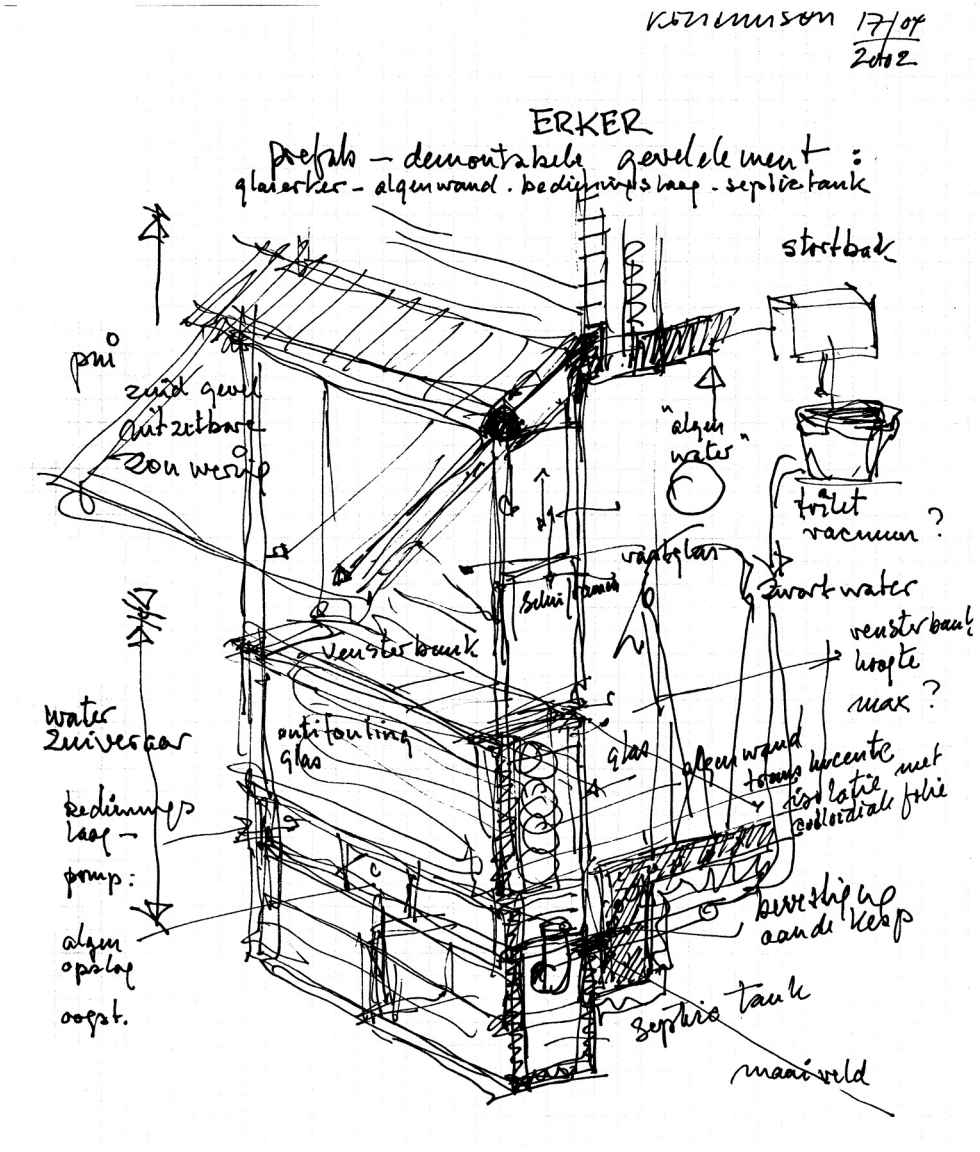

Figure 3. Algae system in breastwork, sketch by Jón Kristinsson 2002

When an algae system is applicated there is no need any more for an external sewer. Only in the building pipes are needed. It is possible to combine functions of building parts with the system. In this case the breastwork has a double function. When different parts are not expected to have the same lifespan it is not wise to combine both. The systems can use the climatological aspects of the house (temperature, light) and some structural (breastwork).

5. CONCLUSIONS

Although some aspects have to be developed decentral sanitation systems are a serious option to replace central systems. A sustainable waste water management can be achieved. This has a large impact on the way we treat our waste. Waste is not waste any more but a source of energy and nutrients. When a shift from central to decentral sanitation is made it is wise not only to investigate sanitation aspects. Also building aspects have to be investigated on different scales: district scale, building scale and on building element scale. It may be possible to combine functions of the building with the sanitation system.

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Evaluating alternative scenarios for existing building stock with the use of assessment tools.

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1. INTRODUCTION

This paper mainly focuses on the evaluation of the effectiveness and environmental aspects of different interventions in existing typical buildings in urban areas with the use of assessment tools in Greece. The tool, which is used for this study, has been developed by the author for the conditions of the Greek industry and will be presented below. The tool, which is described in brief, develops a life cycle profile of a building under various scenarios. It contains the following phases: embodied energy content, the use of transportation, the construction and operation of a building.

Two sets of scenarios are evaluated. The first set mainly examines interactions of embodied energy value changes in the life cycle of buildings. For instance, the penetration of environmental legislation and policies like the integraded pollution prevention and control directive introduces limitations in the construction product industry. The second scenario is mainly concerned with the operational energy of the existing building stock and its environmental releases. Energy improvements with the use of energy audits are evaluated and the results are discussed under the notion of life cycle assessments.

2. THE USE OF ENVIRONMENTAL ASSESSMENT THE BUILDING STOCK

2.1 The building stock

According to the statistical data, more than 85% of buildings in Greece are constructed without the use of the thermal regulation standard, as a result of its late introduction dated in 1981. Therefore, the building sector consumes approximately 30% of all energy consumption in Greece and this results in the emission of +21% of CO_2 emissions. These values refer only to the energy used during building operation. Therefore, there is no picture of the total life cycle energy and emissions of the buildings.

Today, Greece has more than 4 million buildings and it is expected to rise to 4.7 million by the year 2010. In terms of square meters, approximately 11000000 m^2/year are constructed in urban, semi-urban and rural areas. This shows a trend of 1,1 m^2/capita/year. However, there are no available statistical data concerning the built environment in Greece and it is not possible to evaluate the significance of such a trend. Therefore, as the built environment is significant, environmental evaluation of buildings seems more than a necessity.

2.2 Applying environmental assessment of buildings.

The evaluation using an assessment tool can be applied in both existing and new buildings. The environmental assessment, according to Joel Ann Todd et al [1], can be addressed in the

product level, in the buildings level, in the buildings and supporting infrastructure level, in the community level and in the building stock level. In this paper, environmental assessment of buildings is addressed in both existing and new buildings and its uses are presented in table 1.

Table 1 The use of environmental assessment tools in existing and new buildings.

EXISTING BUILDINGS	NEW BUILDINGS
Calculations and assessment of existing buildings in terms of environmental criteria.	Decision making process for material choices and element design.
Creation of the buildings environmental profile.	Evaluation of various scenarios to eliminate environmental aspects.
Benchmark with best practices and improvement potentials.	Assessment of all life cycle phases in terms of environmental criteria and optimization.
Decision making of interventions in terms of environmental criteria.	Benchmark with best available practices.
Study of existing building stock.	Study of the upcoming built environment.

2. THE TOOL DEVELOPMENT

2.1 The need of a new tool in Greece

Environmental assessment tools for buildings have not yet been introduced in Greece. Countries that have introduced such schemes in a non-mandatory base, as in the European level: the UK with BREEAM, or the Netherlands with ECO – QUANTUM, have already understood its need and added stakeholder value. Their penetration rate is considerably high due to a well-based framework of sustainable construction and their approval by the construction sector.

The Greek market however, for the following reasons is showing an "overdue" to this trend. Basic reasons recognized are:

- The absence of an energy code. The compliance with the EU regulation 93/76/EU resulted in the development of an energy code, which is expected to be ready by the end of the current year (2002).
- The absence of an intergraded legal-legislature framework in environmental terms for the construction sector.
- The non-developed integration of sustainability issues in the construction sector.
- The ignorance of environmental issues by the construction industry.
- The recognition of the environmental aspects in general as a supra-normal cost.
- The ignorance or avoidance of the environmental assessment tools.

Nonetheless, as of today, priorities are focusing on areas that include the improvement of energy efficiency in all sectors, including buildings using best available techniques (B.A.T), the development and the observance of the environmental protection legal framework, and the incorporation of sustainability in general. With this in mind, one can denote that the above listed barriers will soon be removed. Thus, the development of a tool was necessary in order to import environmental aspects in the assessment of buildings. The tool is called oikosoft.

Considering the above, the newly developed tool adjusts with the following objectives:

- The compliance with environmental regulations, especially B.A.T. and energy use minimization. In buildings, this means applying B.A.T. in construction material production, leading to lower embodied energy, and measures that result in low energy use during their operation phase. These scenarios are examined later on in the paper.
- The use of the LCA technique as the basis of the inventory phase of the environmental assessment methodology. With LCI, data is collected and calculation procedures are performed.
- The use of local values in terms of embodied energy and operational energy. The study of embodied energy answers to all building phases, i.e. the production of materials, their transportation to site and the construction process.
- The need to incorporate all building phases of a building in result determination. The results determine all the environmental – energy attributes of buildings and its elements for all life cycle phases. These are listed in table 2.

Table 2 The environmental – energy attributes calculated by oikosoft.

Life cycle energy	Air Emissions	Indicators
Operational (heating – cooling, electrical appliances, lighting)	CO_2	GHG
Embodied (material production, transportation, construction process)	SO_2	Acid rain
	NO_x	Photochemical smog
	CH_4	

2.2 Tool description, main functions and results

The tool oikosoft allows the user to design or introduce all the construction solutions - elements of the building. It includes 40 typical construction solutions (mainly used in Greece) for floors, roofs, external and basement walls, structural framework, in which the user can adjust layer thickness or use another material over a list of 130. For the external building elements, the tool provides information on whether the elements are in compliance with the Greek thermal regulation standard. This feature is mainly required when designing new buildings or when designing various interventions of the external building envelope.

Next, the user is asked to complete data concerning the transportation of materials to site, the construction process and operational phase. The tool specifies types of vehicles for every type of material that is transported. Vehicle specifications are contained in oikosoft databases (fuel consumption/km/material and emission factors/km/vehicle). The user fulfills the transportation distances per building material. In case this is not possible, default values are given, reflecting the transportation conditions in Greece. For the construction process, the tool calculates the following: a) earthworks b) concrete pouring c) on site mortar production. For every process, the tool in its database incorporates construction equipment specifications as fuel consumption/m^2 and emission factors/m^2 of building. The construction process step works with the data given for the building under study. Finally, in the operation phase of the building, the user can either import data resulting from an energy audit, or a simulation or can calculate operational energy with the use of degree-days. Within the tool, a list of heating and cooling degree-days are available for major cities in Greece.

Having identified and calculated all building materials, including secondary ones used in the building and its life cycle processes, the tool calculates the environmental attributes of the building which are: embodied energy, CO_2, SO_2, NO_x, CH_4 emissions. The tool calculates these values per square meter m^2 for the total building and for every life cycle phase.

Embodied energy figures, which the tool uses, are derived using process analysis in typical manufacturing industries in Greece. Having the energy mix used per construction material, with the use of emission factors, emission equivalents are calculated. It is useful to mention that electricity is also included in the energy synthesis of materials production. The electricity mix in Greece is mainly based on lignite and this results in high CO_2 equivalents.

3. THE SCENARIOS UNDER STUDY

As mentioned above, the tool can be applied on both new and existing buildings. This paper focuses on the case of existing buildings and in scenario analysis, which aims to evaluate the effectiveness and environmental aspects of different interventions. The scenario approach is the means for investigating important decisions and enables decision makers to detect and explore various results.

3.1 The alternative scenarios under study

As previously mentioned, two sets of scenarios are evaluated and are compared with the existing situation. The first scenario examines interactions of embodied energy value changes when applying environmental legislation and energy measures in material production. It is called low embodied energy scenario. The second is mainly concerned with the operational energy and examines interventions in the external building envelope.

3.1.1 Low embodied energy scenario. Through this scenario, we examine the reduction of embodied energy in buildings as a result of best available technologies BAT, which is specified through the European legislation IPPC (96/61/EC). The reduction of embodied CO_2 is achieved through the least used energy and the penetration of environmental friendly fuels in production like natural gas. The resulted values have been calculated in other studies and some typical results are presented in table 3. The tool calculates and compares the low embodied energy scenario with the existing situation.

Table 3 Typical embodied energy and embodied CO_2 reductions for main construction materials with the use of BAT and other environmental legislations.

	As usual scenario		**Low embodied energy scenario**	
Material	Initial embodied energy (MJ/kg)	Expected embodied energy (MJ/kg)	Initial Embodied CO_2 ($grCO_2$/kg)	Expected Embodied CO_2 ($grCO_2$/kg)
Concrete	1,342	1,1206	350,27	292,5
Reinforcement	31	20,41	6982	1659
Glasswool	42,7	22	4377	1460
Ceramic tiles	3,5	3,08	169,5	149,1
Water	3,6 MJ/m^3	2,55 MJ/m^3	1031 $grCO_2/m^3$	731,5 $grCO_2/m^3$

3.1.2 Intervention scenario contributing to low operational energy. Through this scenario, we examine operation energy reduction of the existing buildings as a result of interventions mainly in the external building envelope. Basic interventions are the insulation of the external building envelope (roofs, external walls, external structural framework) and the replacement of single glazed windows with double glazed windows. For buildings that are not insulated, through this simple technique, we can reduce operational energy by more than 30%. However, as embodied energy is added, it is necessary to examine the energy and environmental release balances in case that the final summations have a greater load than the

existing situation. Finally, interventions need to be studied in economic terms. It is also important to examine indicators like payback period, NPV or IRR. A critical factor for this scenario is the age of the building under study and its remaining operational life. It is obvious that for buildings with limited remaining operational time, any type of interventions leads to negative energy and environmental loads as well as payback periods longer than the remaining time.

4. CASE STUDIES AND RESULTS.

The case studies examine two typical buildings that are located in Greek urban regions. The operational life cycle is estimated at 80 years. The first building is constructed in the decade of 1970 and is 3 floors. The thermal regulation standard is not fulfilled (U_{build}=2.503 W/m^{2}k - U_{regul}=0.808 W/m^{2}k). The total building area is 724m^2. Improvements in the external building envelope contribute to 0.29GJ/m^2/yrs and are accomplished with the insulation of roof and external walls with a 7cm polystyrene layer, ground fool with 4cm polystyrene layer and replacements of single glazed windows with double ones. [3] When applying the tool, we get the following results in terms of environmental assessment. (Table 4)

Table 4 Environmental assessment results for the existing situation, the low embodied energy scenario and the low operational energy scenario.

Tt en/m^2/yr	Eb.en/m^2/yr	CO_2/m^2/yr	CO/m^2/yr	CH_4/m^2/yr	NO_x/m^2/yr	SO_2/m^2/yr
0.7169	0.0771	0.11	0.0000356	0.0012	0.0002407	0.000712
0.700	0.0681	0.1051	1st Scenario			
0.508	0.0985	0.0853	2nd Scenario			

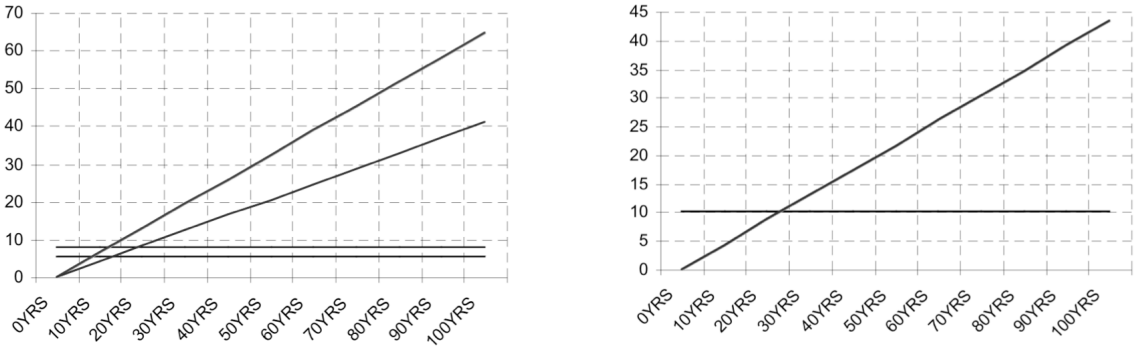
Through the application of the low operational scenario, we achieve a reduction of total energy (operational + embodied) in the absolute number of 29% and a reduction of CO_2 emissions of 22%. This investment has a payback period of 17.6 years and therefore it should be applied. It is also important to mention that with the introduction of the low embodied energy scenario we can achieve reductions of 2.35%, which can be significant in an overall energy minimization.

The second building was built in the 1980's. It has 6 floors, with a total area of 1065.39m^2. Even if it is insulated, it is does not fulfill the thermal regulation standard. (U_{build}=1.244 W/m^{2}k - U_{regul}=0.829 W/m^{2}k). Improvements in external building envelope contribute to 0.0243GJ/m^2/yrs and are accomplished with the insulation external structural elements with a 5cm polystyrene layer.[2] The payback period for this investment is 8.4 years, which is considerably low. Using the oikosoft tool, we get the results for all alternative scenarios for the building under study. (Table 5)

Table 5 Environmental assessment results for the existing situation, the low embodied energy scenario and the low operational energy scenario.

Total en/m^2/yr	Embodied en/m^2/yr	CO_2/m^2/yr	CO/m^2/yr	CH_4/m^2/yr	NO_x/m^2/yr	SO_2/m^2/yr
0,561	0,127	0,1031	0,0000741	0,0007032	0,0002	0,00064
0,542	0,108	0,0918	1st Scenario			
0,561	0,1371	0,0975	2nd Scenario			

In this case study, we can see that the total energy consumption is reduced only when using the low embodied energy scenario. Furthermore, in the scenario where we are trying to minimize operational energy with interventions in the external building envelope, even if



there is a short pay back period, it increases the environmental loadings. The reduction of energy implies reduction of 132,63 tons of CO_2 emission in the remaining operational lifetime, while the embodied CO_2 emissions for this intervention are 179,7 tons of CO_2. Therefore, the remaining CO_2 emission balance is negative in terms of environmental loadings and the intervention should not be implemented with environmental criteria as a driver.

Figure 1 Comparison between operational and embodied energy (GJ/m^2/year) for the two case study buildings using the alternative scenarios under study.

5. CONCLUSIONS

Considering these two case study buildings as being typical for the Greek urban areas, we can conclude that the environmental – energy situation in the building stock can be significantly improved. This paper has studied two alternative scenarios. Beginning with the potential of embodied energy reduction for new buildings that are constructed every year, it is about 1.5GJ/m^2 and represents the 2.33% of the country's total energy consumption. In terms of embodied CO_2 releases, reductions can be up to 10% of the country's total emissions. These figures however, are related to future buildings constructed per year. Therefore, in this discussion, we should add the existing building stock. It was proved through the examples above, that interventions of the external building envelope are accepted only when examining entirely non- insulated buildings due to emission release balances. Operational energy reductions can be up to 30% and this addresses reduction of approximately 7% of the country's total energy consumption. In terms of CO_2, these reductions contribute approximately 4% of the country's total emissions. The significance of these results can be easily understood.

Environmental assessment tools, when adjusted to local conditions, can be very effective for the evaluation of existing and new buildings. Through the use of alternative scenarios, these tools can play a decision-making role, especially when designing new buildings or interventions in existing ones. However, supporting financial strategies should be taken in order to achieve these improvements. New strategies therefore are required for the construction industry expressed as development of action programs, responsibilities and budgets.

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Earth Construction in Uvwie Local Government Area (Delta State, Nigeria)

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1. INTRODUCTION

The idea of this write up is to let people practically know how to build, work and live with earth and what they can gain from it. Practically, we want to re-establish earth construction in Uvwie Local Government situated in Delta State in the south of Nigeria. Uvwie with heavy rain during raining season and very high humidity during dry season is suitable for earth material because the houses built with earth will be well insulated and provide excellent indoor climate. Apart from this big advantage, earth construction is cheap and creates local employment – if you do it the right way.



Picture 1 Examples of Earth Architecture

1.1 Re-establishing earth construction in Uvwie

The journey will take off from simple selection of a soil to construction. Soil varies from place to place so it will be very important to start by teaching users in Uvwie the simple way of recognising the type of soil around them. This first experience will go a long way to establish their confidence that the soil they see everyday is actually what will give them without much income a decent home. It will surely fulfill the dream of many. I will endeavour to show them a simple method from the many existing ones to make it easier and less cumbersome and give them the necessary information for the beginners.
After they go through the stages they will realise the high quality that is associated with earth material. It will become very clear to them that those palaces they see around them everyday without wrinkles are actually of earth material and that is why they are still standing.

The important thing will be the practicals as it is the bed rock to this knowledge. You must do it and get yourself dirty. You must use both head and hand to understand the fundamentals. It

will be important also to make them tour those earth houses around them to take a second look.

In this article, I give an overview about the most important aspects of re-establishing earth construction in Uvwie.

2. WHAT DOES BUILDING WITH "EARTH" MEAN?

Earth is the breaking down of rocks by weathering, the decomposition of vegetables and plants matter, it is a compound matter made up of solids, water and air. The earth is made up of layers of varying texture, colour and depth. The main division is three and that is the top soil, subsoil and bed rock. The top soil is mainly organic materials, while the subsoil is little organic matter and the bed rock a strong stone. The area mainly used for earth construction comes from the subsoil region while the top soil is discarded as a result of its organic nature. Its colour is mainly dark and it is good for replacement after construction.

Just like unreinforced concrete earth is good in compression, but bad in tensile strength therefore walls have to be very thick in order for the forces to pass within the wall to the ground. In this case earth loading bearing walls must be very thick and massive. At the same time, thick walls have very good insulation against heat from outside, thus providing high climatic comfort. One problem, however, will be water as Uvwie is highly a wet area but this menace can be contained by protecting the walls from contact with moisture. What I mean by this is that the base of earth walls must stay dry, it should not be affected by damp. It is easily done by using an impervious material for foundation like stone or concrete. It can also be done by wrapping a protective cover round the foundation such as bitumen or plastic being conventionally used. In Uvwie we source for a stone foundation or protective cover locally to sink the cost down and reduce negative environmental impacts. For example in the north of Nigeria a local material known as "laso" is used to protect water dissipation into flat roofs. There is surely an existence of a material that can stop water infiltration in Uvwie and that will be part of a research. Another way of protection walls of earth building is by using overhangs. Now overhangs are the extensions of roofs at a certain distance away from the surface of the walls. It could be 50cm, 80cm or more: It depends on the position of the building and direction of winds. When rain falls and water comes off the roof the overhangs will protect the falling water from splashing on the surface of the building. When the water falls on the ground there is also need to get it away by compacting a protective slope pavement round the building. This slope will lead the water away from the base of the building and thereby keeping the foundation always dry. This will increase the life span of the building.

3. WHEN TO CHOOSE BUILDING WITH EARTH?

The *material is cheap* when you find it right on site; if it has to be transported by car it will be expensive with respect to finance and with respect to environmental impacts. Therefore, in our case we want to focus on a situation where it can be found on site.

The *construction cost is low* when compared with conventional construction methods if you avoid locations that will increase cost, such as a marshy area where foundation will have to be very deep and therefore will add to the cost.

Important is the *type of roof* and how long will it take until it needs replacement. From the past we learn that the Benin tribe of Nigeria used wood shingles for their roofing until colonialism started and it was replaced with corrugated iron sheet. Obviously this new roofing

material is not the best for tropical climate like in Uvwie and we now know that it was used for economical gains. But with the new awareness as Vivida for Better Life is determined to bring it to the people of Uvwie we go back and investigate how this wood material for roofing was used. From the research we have done we comprehend that it is a hard wood readily available and it can last a long time. It is also water tight. The Benin palace for example before its conflagration used wooden shingles and it lasted for more than 400 years. So these are the areas we focus our research to find a way back to the old roofing materials. The wooden shingles of the past gave the building of that time the distinction of a home. This distinction can be regained.

From the paragraphs above you see, that before to start with earth buildings one very important ingredient that requires careful analysis is the availability of resources.
It must be very clear

- that suitable raw material is available on site or at least should not be far away, and
- where the house will stand.

4. WHICH SOIL TO CHOOSE – THE SUITABLE SOIL

The composition of soil varies in proportions, and there are four grades of particles that are generally accepted.

Gravel	60.00 mm	to	2.00 mm
Sand	2.00 mm	to	0.06 mm
Silt	0.06 mm	to	0.02 mm
Clay	less	than	0.002 mm

The gravel, sand and silt are made of different size particles of rock and they form the stable body of a soil. These three need a binder which is the clay, the material that glue all three together.
In order to choose the right soil, you have to prepare soil samples.

4.1 How to prepare soil samples

Break up any lumps and do the sensory observation:

1. Visual observation
2. Touch
3. Smell

These three above are normally for the experienced earth builders. The beginners will learn by observation and it requires some time. Familiarising oneself with the material will increase the knowledge of touching and knowing the right earth or just simple smell.
Field test is also paramount because it will determine the composition of a soil, establish the optimum water content and establish the plasticity of the soil. By optimum water content I mean the amount of water in the soil at the time you perform the test. The water content is crucial in determining the compressive strength of the material. Now when a wall is constructed the amount of water present during ramming will determine the strength of the finished wall. It is said that the compressive strength of the wall will improve with the dry density of the soil which means the weight of solid material in a given volume. Simple tests are performed to find the optimum water content. These are the bar test and the drop test.

Let me give a simple description of a bar test:
Mix a moderate sized ball of soil and water. Let the soil be soft and consistent and place it on the ground. Now get a reinforced bar of 50cm long with a diameter of 10mm and place it on

the surface of the soil without pushing it. Watch to what extent the bar will push itself to the mix. If it pushes itself to 2cm you know that the water content is right for testing.

While in the bar test a tool is required in the drop test no tool is needed. The drop test is nothing than making a mould of soil with water and at shoulder high to let it drop on the ground. You will then observe what transpires to the soil.
The following can happen:

- The soil will stay in one piece: it is too dry -> use more water and try again.
- With more water it is still one piece: Clay content is high.
- The soil breaks into pieces: Soil is too wet -> allow to dry and try again.
- The soil breaks just into few pieces: the optimum water content is close by.

The above is a clear way of finding the optimum water content. It does not require any sophistication and therefore the local people can learn it fast.

The next is the plasticity. This also fortunately for us does not require any sophistication. I will explain briefly the popular cigar test. This test helps us to know the amount of clay in the soil. To start with you need to take some quantity of soil and wet it then flatten it and form a ribbon about 2cm thick and 20cm long. Make a roll and watch what happens:

- A long ribbon of more than 15cm indicates too much clay: not suitable for building.
- A medium ribbon of about 10cm soil is suitable for building.
- Less than 8cm indicates to little clay: unsuitable for building.

4.2 How to define the soil composition

To define the soil composition, we do a simple particle separation by sedimentation. All that is required here is the jar and a dry sand. The tools are as follows: a glass jar, tape, watch, salt. This is the procedure:

1. mark off one third of glass height;
2. fill with dry sand;
3. add water;
4. add salt;
5. shake vigorously;
6. let it alone for one hour;
7. shake again;
8. let it again for one hour.

At the end you will notice that the gravel settles first then the sand, followed by the silt and lastly the clay. If you do a little arithmetic you will know the percentages of the various particles. The reason for this is to determine the soil composition you need for the construction method you want to use: The suitable soil for ramming contains: sand 45-74%, silt 15-30% and clay 10-25%.

5. CONSTRUCTION STARTS

After all the necessary tests, attention will be focused on wall construction and the emphasis will be ramming which to my judgement will be easier than other methods.
Ramming is a technique used in Benin in those days, and it is not just Benin but many other parts of the world. It is different from the mud brick. Most of the palaces in Benin are rammed earth building. When we talk of rammed earth we are actually talking of the wall construction. It is built vertically between two wooden forms in thin layers of earth in the case of Benin about 60cm high and then compacted with the feet but in the modern technology

with pneumatic tamper. It is built in a horizontal length of about 2-3m long, then the form work is moved first around the building then in ascending layers. Each layer is about 60cm but can be also more to 1m high. In this method the form work becomes very important.
After the first layer is well compacted the form work is moved to the next layer ready to be filled and compacted until it gets to the desired height of the wall.
Construction work in a tropical area will start during the dry season to avoid the heavy down pour. In the past it has been communal effort and I think this spirit of unity in helping self can be brought back to the scene again through the effort of Vivida for Better Life. Site examination will be conducted and the number of people that will participate will be determined through careful study to know exactly what it takes in term of man power to achieve or build a certain size of house. With such knowledge known people will become conscious of the cost and the time. The target will be to start before the dry season and finish before the rain returns.
The items below are the main things to be considered:

1. Excavate earth and remove any lump and stones
2. Sieve
3. There must be no organic matter
4. It has to dry so cover it if there is rain
5. Foundation must be stone or concrete
6. Footing should be 0.5 m above ground level to avoid contact with ground water
7. Form work erected starting from corner of building
8. ramming starts.

The rammed earth shall be built in layers of about 0.5-1 m high. For construction we need: form work, tamp, sack, basket, bucket, water container, hammer, shovel and ladder.

With the above and some interest from the people of Uvwie a new beginning in housing construction can start which will be able to afford the people a decent housing in the new millenium.



Picture 2 Example of Earth Architecture

6. CONCLUSION AND FUTURE OUTLOOK

Inspite of its rudimentary look, earth is a very beautiful building material that can be exploited and used in Uvwie local government area. Its resurgence will mark a new dimension in this

local government area and will give the people a new sense of belonging. Earth building if properly harnessed and carefully brought to the awareness of the people of this community will have the potential to create change towards sustainable development.
It will become known and time will prove it right as volunteers equipped with earth knowledge will take position within the Vivida for Better Life NGO to disseminate the necessary information to the people through teachings and workshops. I as a person with the knowledge of architecture with special interest in earth building will do my utmost best to bring this revived knowledge back to this community. Building with earth is not totally new to the people of Uvwie therefore once the interest is restored through education skills can be developed quickly.

International organisations like the UNO have been preaching shelter for all. How can this be with the astronomical cost for conventional building materials? In this regard there is no way the down trodden masses can dream of a decent home where they will have the opportunity to enjoy a minimum life comfort. But I am very sure and convinced that with this God given earth material found all over in the world and a good study of it plus the desire to help those financially handicapped housing can be made available. Earth building will do the miracle of housing for all and therefore requires a proper attention. Teaching it will be based mainly on practicals and tools will be made available to create familiarity. Every necessary idea will be employed to make the teaching easier and interesting to attract people of Uvwie to it.

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A Simplified Weighting Method for Environmental Impacts

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1. INTRODUCTION

In general, environmental assessment methods apply different weighting methods. In ISO 14042(1999), weighting is referred to as "an optional procedure to rank or possibly aggregate the indicator results across impact categories". The aim here is to simplify and clarify the weighting process, so that it gives room for discussion, and in sensitivity tests. Subjective factors should be clearly stated and kept to a minimum. This project was initiated because of the need to establish transparent and easily understandable weights in the environmental assessment system, EcoEffect (Glaumann 2000).

The most common method of establishing weights in a system of environmental assessment is to let panels argue and vote for weights. The larger and more diverse a panel group is, the more credible are the weights. However, it is difficult to find groups of people who are unbiased with respect to the environment: even a researcher will tend to be biased (Kortman *et al.* 1994). Howard (1998), however, found a reasonable consensus on many environmental issues among seven different panel groups, mostly related to the building sector.

Since decisions that aim to reduce or eliminate environmental impacts do so with the aim of avoiding damage to both human beings and the environment, estimated damages would seem to be a relevant basis for weighting. Weights based on damage can be successively developed as new knowledge is gained; weights based on other principles, such as economic values, opinions, or political goals, may, in virtue of changed circumstances in society, suddenly become irrelevant.

2. DESCRIPTION OF DAMAGE

The main groups of environmental damage are often referred to as harm to *humans***,** harm to *ecosystems*, and *depletion of natural resources***.** Below is shown only the procedure to establish weights for harm to humans.

Our suggestion is that damage to humans is calculated as the product of the number of affected individuals times the average degree of suffering by an individual. In the long run, different kinds of serious suffering will result in premature death. The number of lost life years(YLL) due to different kinds of diseases or other kinds of harm is used to describe the degree of suffering. These numbers are taken from the DALY, Disability-Adjusted Life Year method (Murray and Lopez 1996), which includes terms for both years lived with a disability (YLD) and years of life lost (YLL). For a majority of serious damage to man associated with environmental impacts, the YLL represents some 80-90% of the DALY value. For the sake of simplicity, we only take YLL into consideration here.

Several environmental problems will last for generations ahead. We therefore need to construct scenarios, as in Figure 1.

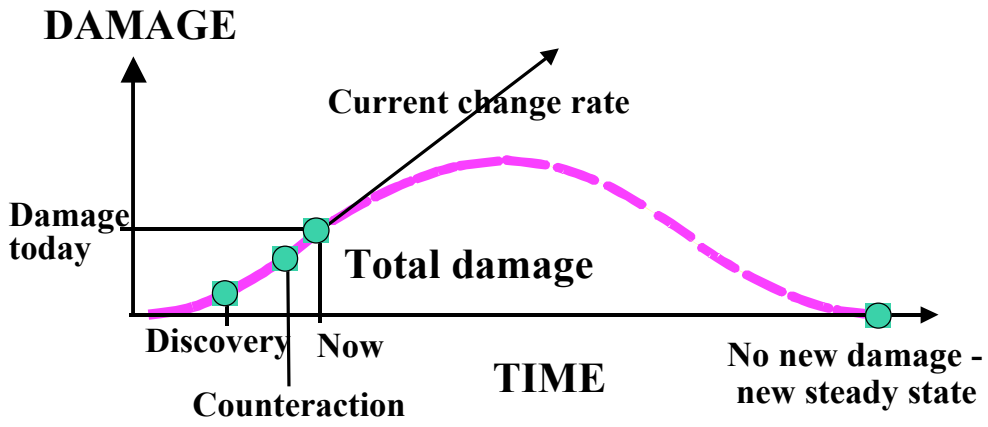

Figure 1. Fictive general damage curve

Every kind of damage is supposed to end some time in the future. The area under the damage curve represents total damage, and this *damage value* can be used for the comparison of different kinds of damage. The simplest approximation to total damage is represented by a triangle, with the duration as the base, and maximum damage as the height. The total damage also corresponds to a rectangle on which one side represents the duration, and the other side represents half the maximum level of damage. Since YLL is a constant for every disease, a corresponding curve can be drawn with the number of people affected per year (incidence) on the vertical scale.

Since we prefer to work with dimensionless figures, we define a damage value as:

Damage value = severity weight x **duration weight** x **extent weight**
Severity weight = YLL/average life time
Duration weight = log(duration)/log(100 000 years)
Extent weight = log(no of hurt)/log(total population)

2.1 Severity weight

The determination of health problems that are associated with different kinds of environmental impacts is achieved through a fate analysis. This shows the chain of events from human needs and activities through to potential damage. The result of the weighting process is of course dependent of how different activities can be related to certain types of damage, and which of them are chosen for calculation of a damage value. To show the fate analysis makes it clear what the weights are based on.

Corresponding to YLL that is used to determine severity to human health, a similar idea can be used for assessing harm to ecosystems by assessing loss of growth compared to an unaffected population.

2.2 Duration weight

The duration of some potential environmental impacts is extremely long. It will take 100 000 years before radiation from nuclear waste has been reduced to the natural level for uranium. From this perspective, a problem that lasts for 50 years would not show, but it would certainly be more or less problematic for those living during this period. In general, we can assume that environmental threats, which will occur in the near future are perceived as worse than those that will occur in the distant future. For this reason, we suggest using a logarithmic scale for calculating the duration weight. 100 000 years is taken as the longest effect period and assigned a weight of 1,0.

2.3 Extent weight

Unlike the duration weight, the extent of damage, expressed in terms of numbers of new cases per year, is unique, but not necessarily different for each type of damage (disease). The focus here is on the maximum of the number of new cases per annum. Harm to humans may, in the worst case scenario, affect everyone on the earth: that is, about 6 billion people. If all people are considered to have the same value, the killing of some thousand individuals means nothing in comparison to the whole of humanity. But from the perspective of a specific place or region, this would be a catastrophe. It seems justified to also use a logarithmic scale in this case, which takes into consideration a damage in the immediate environment, although it may be negligible from the global perspective. The extent of damage is thus related to the affected population, and can be appropriate to study on a local, regional, or global level.

3. ILLUSTRATION

In EcoEffect, which is partly based on EDIP (Wenzel *et al*. 1997), the following potential effects are considered: global warming, ozone depletion, acidification, eutrofication, ground ozone formation, human toxicity, and ecotoxicity, related to a range of emissions. Below we show how to implement the suggested method, taking a global warming and ground-level ozone as examples.

3.1 Global warming

3.1.1 Severity. There are studies that the positive and negative impacts of global warming. Accounting for the uncertainties that lie behind such studies, and conforming to the precautionary principle, in our case we focus only on negative effects, sticking to idea that negative impacts cannot be compensated by positive impacts. The damages (diseases) considered with their severity weights are: malaria (0.50), dengue fever (0.54), increased cardiovascular diseases (0.12), and increased respiratory diseases (0.39). Taking the number of deaths resulting from each disease into consideration, a weighted severity average of 0.28 is calculated for global warming.

3.1.2. Duration. CO_2 is responsible for 60% of the anticipated global warming, and the content of it in the atmosphere has increased substantially since the early nineteenth century, mainly due to the combustion of fossil fuels. The atmospheric load of CO_2 is now over 765 billion tonnes of carbon (GtC), an increase of around 175 GtC over pre-industrial levels. In 1992, the IPCC generated six scenarios (IS92a-f) of future greenhouse gas and sulphur emissions, related to emission of carbon into the atmosphere, over the period 1990-2100 (Leggett *et al* 1992). In scenarios c and d, the emissions culminate in about 2030, but these scenarios are claimed not to be realistic. For the other scenarios, emissions are still increasing at the end of 2100. We chose a scenario lying somewhere between IS92a and IS92f, with emissions presumably culminating around 2150. In this case, the global warming problem covers a period

of 700 years all together. All damages are supposed to be directly related to this duration of global warming with the same duration weight of 0.57.

3.1.3 Extent. Damage to human health caused by climate change has been calculated by Tol (2000). Based on his results, developers of Eco-Indicator 99 (Pré 2000) have made further calculations of the number of deaths associated with the emission of carbon, methane, and laughing gas for two time horizons up to 2100 and up to 2200. From these numbers, we have calculated corresponding values for 2150, our anticipated culmination time, and arrived at the following numbers and extent weights:

Table 1 Extent weight for global warming

Damage	Estimated no of deaths/year 2150	Extent weight
Malaria	248 204	0.55
Dengue	5 867	0.39
Cardiovascular	373 680	0.57
Respiratory	47 899	0.48
Sum	**675 650**	**0.60**

3.2 Ground-level ozone build up

3.2.1 Severity. Ozone, O_3, is created through chemical reactions between solar radiation and gases such as nitrogen oxides and volatile organic compounds (VOC). These gases have increased due to human activities. Ozone formation increases with temperature. Sources of these gasses include vehicles, combustion, and the use of solvents.

Human exposure to elevated levels of ozone concentrations can give rise to inflammations, aa decrease in lung function and increased mortality. Observable symptoms include coughing, chest pains, breathing difficulties, headaches, and eye irritation. Studies indicate that exposure to ozone concentrations in the range of 160-360 mg/m^3 for a period of 1-8 hours, often observed in Europe, reduces various pulmonary functions. Once exposure ceases, lung function returns to pre-exposure level (Beck *et al*. 1998 and De Leeuw *et al.* 1997). Considering people above 75 years old to be at high risk of an earlier death, with YLL of 5, the severity weight becomes 0.063.

3.2.2 Duration. Compilations done so far in Sweden show that the emissions of nitrogen oxide have decreased during the last decade with about 20 % probably due to the use of catalytic converters in cars. The Swedish Environmental Protection Agency claims that emissions must be reduced by 75-80% to achieve levels which do not hurt man and plants.

Since the end of the nineteenth century, the concentration of ozone has doubled, and during the 1970s it increased by 1% per year. Road traffic has doubled during the last 30 years, and seems to continue to rise, albeit possibly at a slightly lower rate. Nevertheless, it seems the release of NOx culminated during the 1980s, and we guess that the problem of high levels of ground ozone will continue for at least another 20-30 years, giving a duration weight of 0.52.

3.2.3 Extent. High ozone levels mainly occur in high-density areas. Ozone levels have been recorded in European cities. During the 1990s, the threshold value of 110 μg/m3 was exceeded on 20-30 days per annum. In Sweden, a threshold of 80 $\mu g/m^3$ has been adopted to protect the more sensitive members of the population. One estimate suggests that these im-

pacts may have led to over 3000 additional hospital admissions in the full population of 15 EU countries (Beck *et al*. 1998). According to a Swedish study increased levels of ozone above average values are associated with increased mortality of about 2% for every increase in concentration of 10 μg/m^3 (IMM 2001). In European cities ozone levels above 110 μg/m^3 occur about 20-30 days per year on average (EEA 2001). This corresponds to an increased mortality rate of 6%: that is about 450 deaths per year in Sweden (SOS 2001), which gives an extent weight of 0.39 for the urban population.

4 CALCULATION OF DAMAGE VALUE

Once the values for severity weight, extent weight, and duration weight are calculated, the final step is to calculate the damage value (DV) for the impact category in question. This is given by the product of the weights: for global warming: 0.28x0.6x0.57 gives a DV value of **0.096**; and for ground-level ozone: 0.063x0.39x0.52 gives a DV value of **0.013**.

The contribution of each disease to the global warming total damage is shown in Table 2.

Table 2 Contribution of different types of damage to the total damage of global warming

Damage	Estimated no of deaths/year 2150[E]	Severity [S]	Damage [ExS]	% contribution
Malaria	248 204	0.5	124102	65
Dengue	5 867	0.54	3168	2
Cardiovascular	373 680	0.12	44842	23
Respiratory	47 899	0.39	18681	10
Sum			190792	

After calculating the damage values for each impact categories, the weight of an impact category becomes the ratio of its damage value to the sum of all damage values.

5 CONCLUSION

The damage, which we defined as a product of severity and extent corresponding to the risk associated with different impact categories, seems to be a proper basis for weighting. The damage value based on approximating the damage-duration curve with a triangle seems also to provide a reasonable model. Accuracy depends on how well the triangle approximates the precise shape of the damage curve.

Since the future effects of today's emissions are basically unknown, a combination of historical emission trends and scenarios are used to arrive at the weights. The scenarios in some cases are relatively well established, whereas there are cases in which there is so much uncertainty embedded that mere estimation is a used until further knowledge is acquired. In such cases estimation may be better than nothing until we can replace it with improved values.

Collection of data and statistical information regarding environmental impacts takes considerable time, but even at an early stage of this process, the method can be of use in carrying out comparisons between different impact consequences and weighting across environmental impact categories. The procedure is easy to follow and allows for further improvement.

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Dubo*Calc*: LCA tool for design of constructions in the ground, road and waterworks sector

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1. INTRODUCTION

Rijkswaterstaat (RWS) is the part of the Dutch Ministry for Transport and Waterworks, that designs, commissions and owns the Dutch road and waterworks infrastructure. Sustainable Building is an on-going subject in design processes, maintenance, commissioning and policy making. One of the topics are the materials used in constructions. After several years of experiencing with LCA and material checklists, RWS decided to develop an LCA tool for design: Dubo*Calc*[1]. In 2000/2001 a first prototype is built. In 2002 the functional requirements are drafted, after which it will be decided in which software further development will take place. The database will be filled out in the period April – September 2002.

In this contribution we will show how the tool is built up and we will go into the specific, constructional and LCA, issues that has to be solved before the instrument can be used in daily practice.

2. THE SOFTWARE TOOL DUBO*CALC*

2.1 Why prototyping?

Although LCA was not new for RWS, it seemed difficult to specify full functional requirements at the start of the project. RWS therefore decided to develop a prototype first. Aim of the prototype was to show the input and output of the tool for the user, for demonstration and test purposes. Figure 1 shows the general structure.

[1] Dubo is the dutch abbreviation for Sustainable Building, Calc stands for calculation

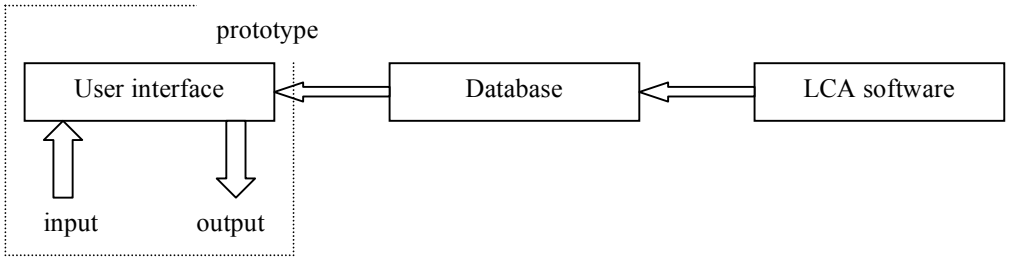


Figure 1 The general model of the LCA tool

2.2 The current prototype

Specific characteristics of the prototype are:

- Input of most structures is possible.
  This was one of the main challenges of the project because of the numerous different constructions and the uniqueness of the constructions (there is no 'standard design' format neither a standard design process). An object-oriented LCA-tool, as applied in LCA-tools for housing (such as Eco-Quantum), seems more user-friendly. However, it turned out that a general tool for road and waterworks should start as a material-oriented tool. Cases can be added later on to serve as object-oriented examples for future use.
  The input is equivalent to the input of cost calculations.

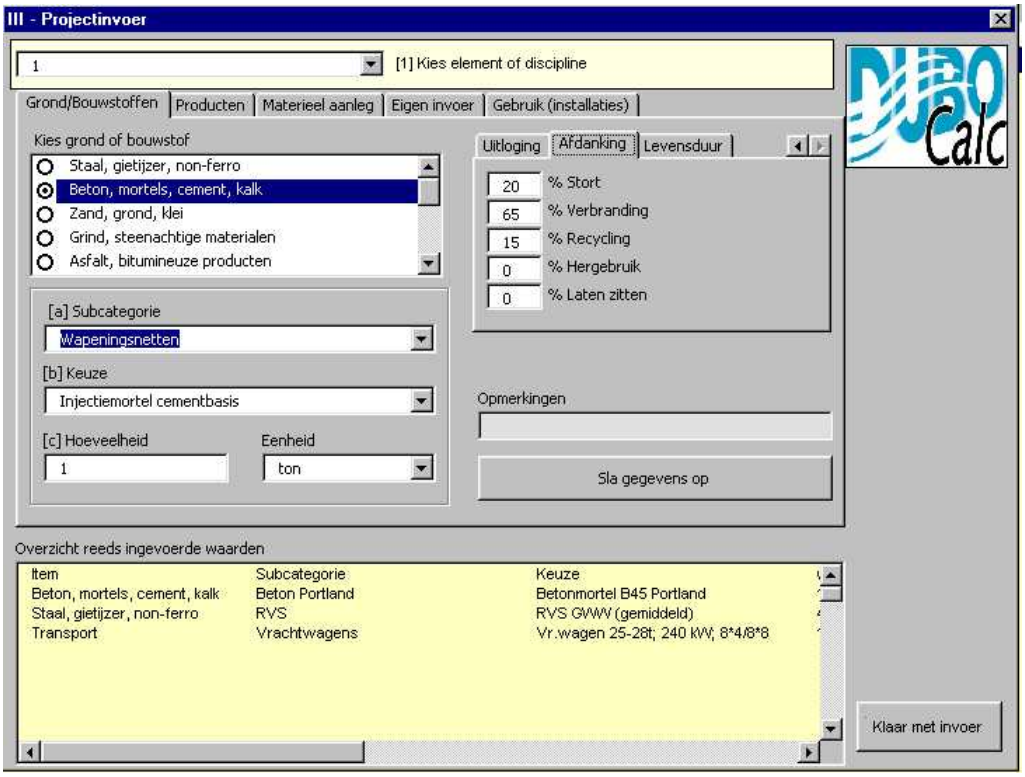
  Note: RWS has an other LCA software tool called 'Keuzemodel Kust- en Oeverwerken' (a model for choosing coastal and banking structures) which is object oriented. This was possible because it deals with one, rather standardised, product group only. Other object-oriented examples are known from the European project TESCOP (bridges and tunnels).

- The most relevant input variables are there for an LCA, but as much as possible in the language of the designer.

Using the tool is straightforward LCA:

- The design is described by it's materials, equipments and processes.
- The tool links these to default processes from cradle to grave: The construction of the process tree is modelled. Those processes that can be influenced by the designer, can be adapted. The database of the tool contains so-called modelling features for this step (see next chapter).
- All processes in the tree are linked to environmental profiles. By adding them, the environmental profile of the structure is obtained.

Figures 2 and 3 show parts of the user interface of Dubo*Calc*.


III - Projectinvoer
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Grond/Bouwstoffen
Producten
Materieel aanleg
Eigen invoer
Gebruik (installaties)
Kies grond of bouwstof
Staal, gietijzer, non-ferro
Beton, mortels, cement, kalk
Zand, grond, klei
Grind, steenachtige materialen
Asfalt, bitumineuze producten
Uitloging
Afdanking
Levensduur
20 % Stort
65 % Verbranding
15 % Recycling
0 % Hergebruik
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Item
Subcategorie
Keuze
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Beton Portland
Betonmortel B45 Portland
Staal, gietijzer, non-ferro
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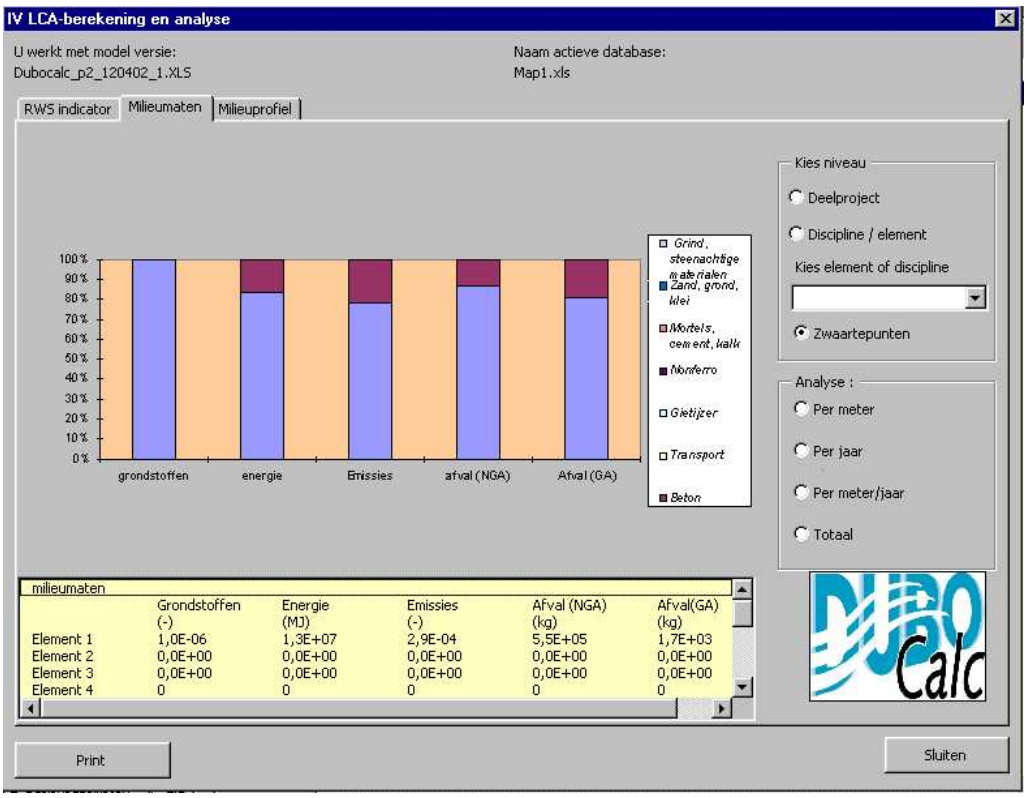
Klaar met invoer


IV LCA-berekening en analyse
U werkt met model versie:
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Map1.xls
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Afval (GA)
Grind, steenachtige materialen
Zand, grond, klei
Mortels, cement, kalk
Nonferro
Gietijzer
Transport
Beton
Kies niveau
Deelproject
Discipline / element
Kies element of discipline
Zwaartepunten
Analyse :
Per meter
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2.3 Further development

The prototyping was a very useful learning process, ending up with a better defined picture of target groups, desired input and output, possibilities and limitations.
A more refined structure is established now (Figure 4), which is the basis for the database structure and for drafting the functional requirements of the software development.

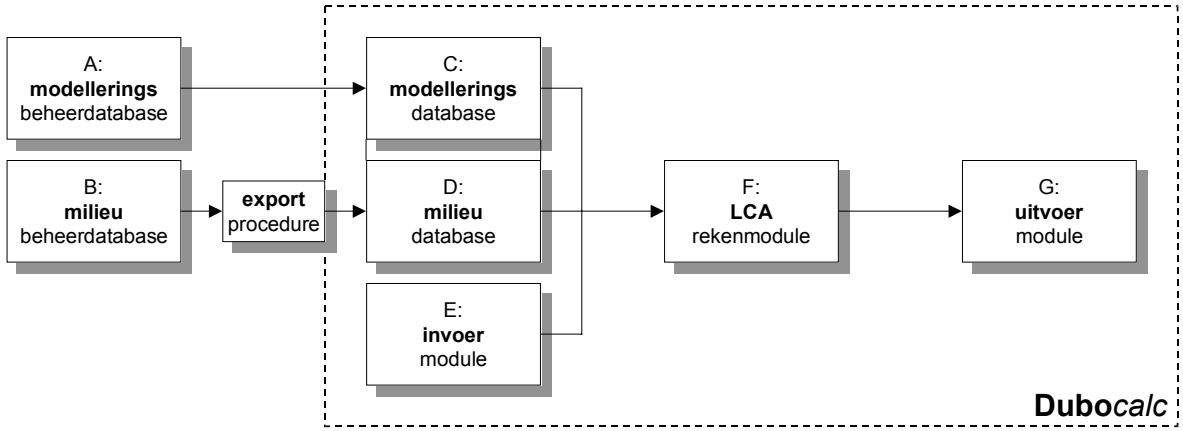

Figure 4 The model of Dubo*Calc*:

- A management of modeling features
- B database for calculation of environmental profiles
- C database with modeling features
- D environmental database with environmental profiles
- E Input module user interface
- F LCA calculation module (impact assessment method)
- G Output module

Currently, the modeling features and the environmental profiles are collected. The management structure of the databases and the features is still under discussion. The LCA calculation module awaits other developments in the Netherlands.

3. THE DATABASE

As shown in Figure 4, the database consists of two parts: modeling data and environmental data. These features will be connected to a list of materials, equipment and processes that is derived from similar list of cost calculations. The list comprises several hundreds of processes for which these data are collected.
An initial data quality is required. This is specified per feature, but the general basis is a Pedigree matrix, as shown in Table 1. The bold level is set as initial level.
By using a Pedigree matrix from the start, the overall data quality is clear and transparant, also for discussions. It also facilitates data quality management in future.

State-of-the-art in LCA of Building and Construction. Results of the SETAC Working Group

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1. INTRODUCTION

Increasing environmental awareness in the Building and Construction sector has resulted in the proliferation of building environmental assessment tools and application of Life Cycle Assessment methodologies.

In 1998, the SETAC Steering Committee created a Working Group to consider the application of LCA in the Building and Construction Sector. The objectives of the group were to identify important characteristics of LCA and propose guidelines or options for methodological choices as well as to propose a set of recommendations for future work. RILEM[1] TC-EID/ECB "Systematics of the Environmental Impact Databases of building materials" group joined the SETAC working group.

The results of this work are reported in a state-of-the-art document. The prevailing message is one of the needs for harmonisation of approach in order to allow LCA results from different studies to be compared and to be used to make meaningful choices in the building and construction sector.

2. RESULTS

The main findings of this report on the topic of LCA and building and construction (B/C) are summarised below.

The Focus for LCA Studies

- The final B/C, defined by performance requirements, is the central subject of an LCA study in the building and construction sector and provides the most accurate subject for any comparison.
  In practice, the products or components of a building or construction can provide a valid subject for the application of LCA. However, the context of the complete B/C shall be reflected or at least mentioned in comparative LCAs of B/C components and incorporated whenever appropriate.

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[1] RILEM the international Association for Building Materials and structures, an international network of technical experts advancing the knowledge of building materials and structures

3 www.setac.org

- It is the designer's responsibility to design the building or construction to a suitable performance and to define the functional equivalence of alternative B/C's. It is the responsibility of LCA practitioners (e.g. with help from manufacturers) to provide suitable Building Material and Component Combinations (BMCC)-LCAs that can be brought together to the B/C-level.

Guidelines for Different Goals

- To undertake a meaningful LCA the whole life cycle of the B/C should be taken into account. The practitioner should undertake quantification of the retrospective life cycle stages (e.g. cradle-to-gate) and assumptions about the prospective life cycles stages (e.g.gate to grave) as appropriate:
- If the goal is to inform users about the environmental impact of BMCCs, cradle-to-gate data are measured and information on B/C subsequent life cycle stages will be based on qualitative or quantitative assumptions. As a minimum, and if applicable, an indication of probable service life and end-of-life scenario should be provided. Information about subsequent life cycle stages should preferably be presented separately in order to allow the next users to use different scenarios.
- If the goal is alternative BMCC comparative assertion, (prospective) life cycle stages of the B/C can be omitted if their performance at these stages is considered equivalent. As a minimum, those B/C considerations should be discussed.
- If the goal is BMCC product development or process optimisation, the B/C perspective can be omitted if it is clear that the B/C (structure or performance) is not influenced by the performance of the newly developed or optimised BMCC. As a minimum the B/C perspective should be discussed.

- True functional equivalence for buildings or components can only be assessed at the level of the whole B/C over its entire life cycle. Comparisons of functionally equivalent B/Cs will be based on a set of B/C building performance characteristics.
  The choice of a functional unit to compare alternative BMCCs should be defined to reflect the functional equivalence of the B/C.
  Primary and secondary functions of BMCCs have to be assessed in the context of the performance requirements of the B/C.

Service Life Scenarios

- There are not yet commonly accepted rules for how to define B/C service life or BMCC service life, frequency of maintenance and replacement. Developments in Service Life Planning to determine actual service life and remaining value of the BMCC will be useful. Actual service lifetimes, based on experience, are generally favoured over potential or maximum technical lifetimes.

- Dynamic Modelling of environment-related durability of BMCCs has been neglected to date and should get more attention.

End of Life Scenarios

- Either ending the life cycle with the generation of waste streams or further accounting for waste treatment are both frequently applied in BMCC-LCAs and B/C LCAs. The waste scenario can be formulated in two ways depending on the study goals:
- The current waste management scenario

- A hypothetical waste management scenario (e.g. based on developing recycling technologies).

If the current scenario is chosen, it is also useful for designers to be able to apply future scenarios, e.g. for a design-for-recycling study.

End-of-life scenarios are country-dependent and sometimes building or site dependent. It is useful to have the freedom to choose the appropriate scenario as well as a common national default scenario.

Allocation

- System boundaries and allocation rules differ between projects and countries. Although there is an international knowledge transfer and growing consensus, a further harmonisation is desired for information transfer of LCAs between studies and countries.

  Multi-input and multi-output processes

  It is the responsibility of the LCA practitioner to use the appropriate allocation principle for products. The allocation method should reflect the causality of material and energy flows.

  End-of-life allocation

  There are different views on how to deal with allocation for long-life applications such as building products and B/C.

  Main discussion points include:

1. the applicability of system expansion to avoid allocation and to apply subtraction methods, especially with regard to the comparability of BMCC-LCAs for combination in B/C-LCAs
2. the applicability of subtraction methods for (semi-)closed loop recycling processes, also especially for BMCC-LCAs to be combined in B/C-LCAs
3. the percentage of recycled material input to allocate to the current product that is being produced. There are mainly two views:

- allocate the current percentage of recycled material only
- allocate the future percentage of material that is going to be recycled

4. the fact that allocation procedures concentrating on the devaluation ("quality loss") of a material over a life cycle can be more appropriate than using factors on recycling rates.

Although this discussion is not building-specific (it is relevant for all long-life products), it is essential for LCA of B/C since the use of BMCC-LCAs in B/C LCAs for comparative purposes is only possible when comparable allocation principles are applied. Ideally LCA data on end-of-life processes should be provided in a non-allocated format to allow decision-makers to choose the appropriate allocation method for the goal of the study.

LCA and Indoor Air Quality

- Hazardous substances are not easily dealt with in B/C LCAs or BMCC LCAs. Under certain conditions, hazardous substances can be released from materials or formed when combining some materials together and these impact building indoor air quality or the factory working environment and result in health issues. Indoor air quality is highly linked to building design.

The relation between LCA and the working environment is being dealt with in another SETAC Working Group

International Differences

- At the moment, declaration/labelling systems for BMCC-LCAs are very difficult or impossible to exchange between actors and countries. Further discussions, development and harmonisation are essential for a successful use of LCA in the building and construction sector

3. RECOMMENDATIONS

Further research for LCAs in B/C is required in the following areas:

- Harmonisation of BMCC-LCAs that will be used for B/C LCAs. There should be a particular focus on harmonisation of system boundaries, modelling of maintenance, definition of end-of-life scenarios and allocation.

Related areas for research, either on-going or needing further attention that will impact upon the application of LCA to B/C include:

- The relationship between durability and environmental effects (dynamic modelling)
- The service life of BMCCs and service life of the B/C and the development of consistent scenario
- Clarification of the interrelation between LCA and EIA
- The ability of LCA to deal with indoor air quality and hazardous substances
- The combination of LCA with LCC

Knowledge transfer and communication is required further to this state-of-the-art report, especially in the field of product declarations and labelling for BMCCs and B/C.

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A Standard for Sustainable Buildings

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1. INTRODUCTION

In the Brundtland Report, the United Nations Commission on Environment and Development gave the most widely accepted definition of sustainable development, that is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987).

Sustainable development – and sustainability as its ultimate goal – is based on the three pillars social solidarity, economic efficiency, and ecological responsibility. These are interdependent. Sustainable development basically aims at stable and just social conditions of living. A sound ecosystem is the prerequisite for the long-term survival of mankind. The economy has to reconcile the demands of ecosystem and society.

A variety of standards exists, which give guidelines with respect to individual ecological issues as well as to sustainability. For buildings, the most relevant instruments are:

- Visions and key figures for national or global development
- Indicators for sustainable development
- Regulations concerning the building sector (e.g. heating energy demand)
- Life cycle analyses (LCA)

While visions and indicators focus on a national or global context, regulations and LCA methods allow for the assessment of individual objects.

The Centre for Energy and Sustainability in Buildings, ZEN, promotes the efficient and intelligent use of energy, and sustainable development in construction. With the ZEN-Standard, the centre aims to link national thresholds for ecological sustainability with ecological targets for individual buildings. The ZEN-Standard was first developed for residential buildings, and is now extended to comprise commercial buildings as well.

2. METHOD

2.1 Overview

The ZEN-Standard describes a procedure to define thresholds for the ecological sustainability of a building and its use. The procedure itself however is applicable to all areas of consumption, production, and services. Existing data bases and calculation methods are used

as far as possible. The relation of input data, methods used, and the procedure of the ZEN-Standard are outlined in Figure 1.

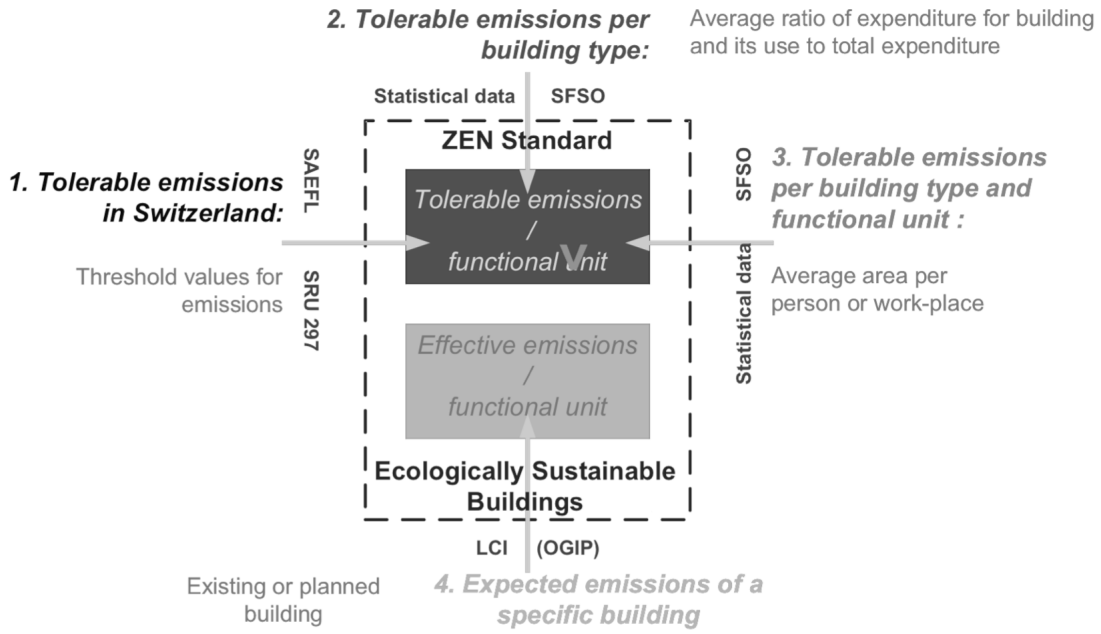

Figure 1 Procedure of the ZEN-Standard.
SAEFL: Swiss Agency for the Environment, Forests and Landscape, SRU 297, see Brand et al. (1997), SFSO Swiss Federal Statistical Office, OGIP, see CRB (1998) .

Ecological sustainability here means a stable state where the environmental load (given as fluxes) is low enough, so that the ecosystem is able to absorb the fluxes without being deteriorated. The most important contributions to the environmental load are i) emissions to air, water and soil, ii) use of resources and iii) land use. At present (see section 2.2), threshold values are derived only for emissions. Therefore, we use the term emission instead of environmental load. But we keep in mind that, as soon as sufficient data on other impacts are available, threshold values have to be defined for them, too.

Three steps are necessary to define threshold values for emissions related to a specific building type, that are tolerable in a sustainable situation in Switzerland, (upper part of Figure 1):

1. The maximum total emissions in Switzerland, which are compatible with a sustainable situation, have to be evaluated. We call them tolerable emissions. The pressure on the environment resulting from the total of human activities in Switzerland may not exceed this threshold.
2. For the building type under consideration, its maximum contribution to the tolerable emissions has to be defined. These are called the tolerable emissions per building type.
3. The tolerable emissions per building type have to be related to a functional unit appropriate for the building type. For buildings, the functional unit is chosen to be gross area. Via the average area per person or per work- place, these values are also related to persons.

Threshold values for the tolerable emissions may be updated due to knowledge gain or changing political judgements. Accordingly, the values evaluated in step 1 have to be

updated. Statistical data may change and therefore require an update of the distribution procedure in steps 2 and 3.

In a 4th step, the object under consideration has to be evaluated.

4. The effective emissions of a specific building have to be evaluated and compared to the tolerable emissions per building type and functional unit resulting from step 3. For the specific building, a LCI (Life cycle inventory) has to be derived. The method and system boundaries have to be compatible with steps 1 to 3.

2.2 Tolerable Emissions in a Sustainable Situation in Switzerland (Step 1)

The tolerable environmental load as defined in the overview cannot strictly be derived on a scientific basis. There still is (and possibly ever will be) a lack of knowledge, e.g. on impact mechanisms, or distribution and interactions of emissions. Moreover, threshold values for certain impacts fixed in laws and regulations are not solely based on scientific findings. They rather represent a political compromise between (estimated) damage to the environment, risks, and (potential) cost of avoidance. However, values fixed in laws and regulations are compulsory, and at least they constitute minimum requirements for a more sustainable future. Therefore, we decide to use officially fixed threshold values as a measure for the tolerable environmental load.

There are no compulsory limits for use of resources and land. This implies that we have threshold values only for emissions. Because in most cases use of resources and land is associated with emissions, they are at least accounted for indirectly. For Switzerland, current threshold values (critical values) and actual values of emissions have been published by Brand et al. (1997). It is expected that the data will be updated regularly.

2.3 Tolerable Emissions Related to Specific Building Types (Step 2)

2.3.1 Distribution Model. Rules have to be established to allocate tolerable emissions in a certain region to different sectors. We assume that inhabitants have the primary right to decide on the "use" of tolerable emissions. The tolerable emissions are equally shared among them. From that, each individuum can determine the personal amount of tolerable emissions, and compare it with his or her actual emissions.

However, starting from the individuum is not a practical approach to evaluate buildings. Future users and their personal life style are usually not known, users may change, and the evaluation of a building and its users are mixed. We take the statistical sample of Swiss households as starting-point instead. A (fictive) member of such an average household is taken as representative for the "average individuum".

We model the economy as a closed cycle of cash-flows between economic units: private sector, business sector, and transfer institutions. In Figure 3, every line represents a cash-flow. We assume that certain cash-flows (thick lines) may carry shares of tolerable emissions. For the evaluation, the business sector is simply divided in two parts: the unit under consideration and the rest. Transfer institutions are defined here as entities that transfer money from households and business to households without service in return (e.g. pensions, sick-benefits and the like). The allocation of tolerable emissions is determined by the allocation of the cash-flow it is associated with. Households are "sources" of tolerable emissions. The business units are the "sinks" of tolerable emissions.

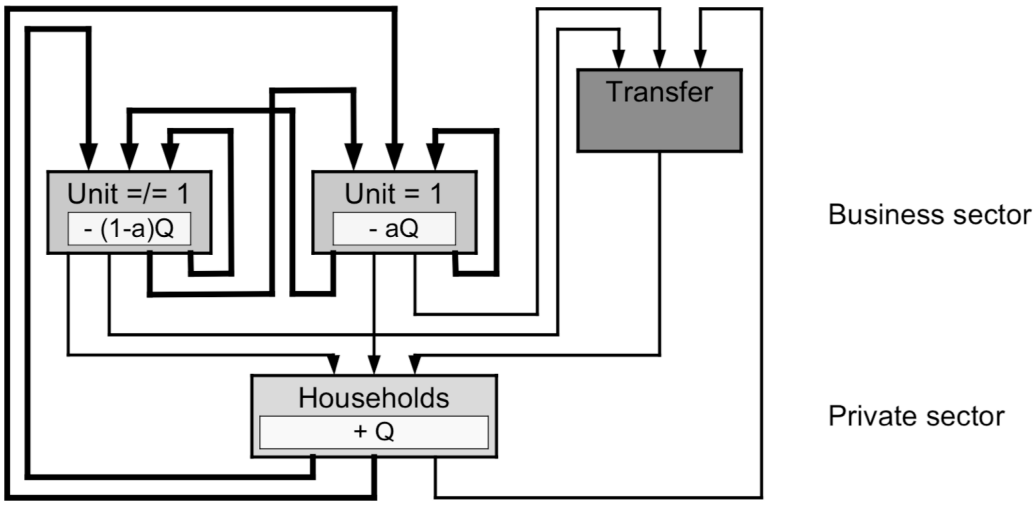

Figure 2 Cash-flows and shares of tolerable emissions transferred with cash-flows (thick lines only). Households are sources, business units are sinks of tolerable emissions.

In the private sector, the allocation of tolerable emissions is related to the average allocation of the household budget, excluding transfer payments. For the business sector, it is assumed that part of the tolerable emissions are retained, and part are further transferred to other business units. I.e., shares of tolerable emissions may be received by business units with their income directly from households or indirectly via other business units. No shares of tolerable emissions are transferred with salaries and transfer payments.

2.3.2 Evaluation of Residential Buildings. In the private sector, the building type is residential buildings. I.e. all areas of consumption that are related to housing are taken into account. These are expenditures on renting or buying, maintaining a house or an appartment, as well as expenditures on energy, and on mobility induced by housing. Mobility induced by housing depends on the location of the house. It includes commuting to job and school, and shopping.

On average, Swiss households spend about 24% of their budget (excluding transfer payments) for housing and energy, and about 4% for mobility induced by housing (Bundesamt für Statistik, 1999a and 1999b). This means, that in Switzerland 28% of the tolerable emissions may be caused by housing.

2.3.3 Evaluation of Commercial Buildings. In the business sector, commercially used spaces or buildings belonging to a certain business unit are evaluated. The evaluation of business units involves more than one step:

- Cash-flow data are not directly available. They have to be calculated from statistical data from different sources from the government and from professional associations.
- Though the total sink strength is known (it must be equal to the source strength), an additional assumption is required to model the sink strengths of individual business units. Then the share of tolerable emissions that is retained and the share that is transferred to other business units can be determined.
- Once the amount of tolerable emissions that the business unit may use is known, the amount of tolerable emissions for commercial buildings in a business unit can be

determined. Their ratio corresponds to the ratio of the total costs excluding salaries and transfer payments, and the costs for building construction or rent, operation, and maintenance .

Several approaches to assign (relative) sink strengths for tolerable emissions to business units are under discussion. Among others, added value, material intensity, and share in gross domestic product are evaluated as distribution criteria.

2.4 Functional Units (Step 3)

Housing comprises all residential buildings in Switzerland. Knowing the average area per person and the number of inhabitants in Switzerland from statistics, we calculate the tolerable emissions for housing per square meter.

Commercial buildings comprise all rooms and buildings used by the corresponding business unit in Switzerland. The average area per work-place and the number of persons working in that business unit must be evaluated. Then the tolerable emissions per square meter can be calculated.

2.4 Building LCI (Step 4)

The LCI for a building has to be conducted with appropriate tools (e.g. OGIP, see CRB, 1998). The material and energy flows for construction, operation, maintenance, and demolition of a building, and for the induced mobility (commuting to job and school, and shopping) are determined. The same system boundaries as used in steps 1 to 3 have to be applied. Average distances per means of transport associated with induced mobility are taken from (Bundesamt für Statistik, 1990).

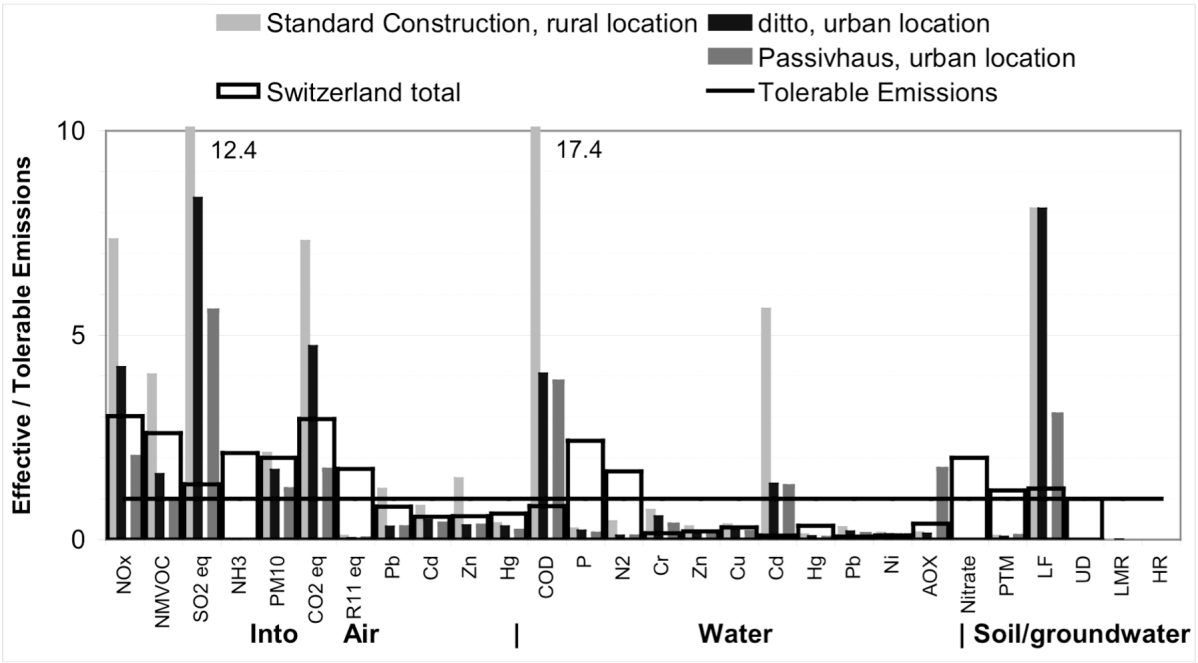

Figure 3 Effective emissions in relation to tolerable emissions (= 1) for Switzerland, and for residential buildings with standard construction, and Passivhaus construction.
Additional abbreviations: PTM plant treatment agents, LF landfill, UD underground disposal, LMR low / medium radioactive waste, HR high-level radioactive waste

3. EXAMPLE

The ZEN-Standard is applied to residential multi-family buildings. Current practice and best available technology (Passivhaus-Standard, see Passivhaus Institut) are compared. Urban and rural situations have been chosen to demonstrate the influence of the induced mobility. The rural location is close to a large city, but the frequency of public transport is low.

Both the construction standard and the location of the building are of great importance. Emissions that exceed the tolerable emissions for housing, are almost always also critical for Switzerland as a whole. Only COD and Cd (mainly stemming from the induced mobility) exceed the tolerable emissions for housing, but not for Switzerland as a whole. The tolerable values for COD and NO_x are exceeded even by the emissions from induced mobility alone. CO_2 equivalents are dominated by heat requirements, SO_2 equivalents by electricity (UCPTE-mix) and induced mobility. Even the most advanced standard (including leight-weight construction) exceeds the limits for some emissions. Continuously growing living area per person increases the problem.

4. CONCLUSION

A standard for ecologically sustainable housing has been developed and tested. The results show that even advanced buildings have difficulties to meet the threshold values. Energy and last but not least mobility remain crucial factors, where further improvements are required.

A framework for applying the standard to commercial buildings that is consistent with the procedure for housing has been developed. The next step is to develop an appropriate criterion for the allocation of sink strengths, and to apply the standard to commercial buildings.

ACKNOWLEDGEMENTS

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A sustainable building designed for a cold climate with extensive use of information technology

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Introduction

In the past, Telenor's operations in Bergen have been spread across many sites and buildings. This was regarded as ineffective and uneconomic, and in 1995, the initial idea of a new building in Bergen started to be discussed.

Telenor's objective for the new building at Kokstad was to assemble the company's creative talent, enhance the company's identity and to take further the company's tradition of being a responsible contributor to society. Telegraph buildings have been central, institutional buildings in all large Norwegian towns – in the same way as the Post Office Building and the Electricity Board Building. In many cases these operations are on their way out of town centres – often moving to regular office buildings where their profile easily becomes anonymous.

Telenor set demanding objectives for its new building in Bergen. The best in traditional building techniques, modern technology, environment-friendly principles and challenging decoration were to be incorporated into the same building. At the same time, the need for effective use of floor-space, energy efficiency and the indoor climate were regarded as sacred.

The Fana landscape

The site is approximately 40,000 m^2 and is situated on Airport Road. It is located at a road junction with the bus station and the future metro-rail station as its nearest neighbours.

The landscape is undulating countryside with forests, marshes, meadows and fields of pasture.

On the southern border is a stone wall, behind which there is a row of large fir trees. Otherwise, there are quite a few large pine trees on the site that are protected by preservation orders.

The road creates some pollution in the form of exhaust fumes, dust and noise.

Prevailing winds are cool winds from the northwest in summer, and temperate, wet wind from the south-southwest in winter.

Like the fingers of a hand

The building is designed with a straight, protective wall facing the street in the north. The main entrance divides the wall into two sections. Facing the sun and the landscape are four wings, like the fingers of a hand.

The slate-floored area in front of the entrance is a part of The Square – the central part of the building – and connects the entrance side of the building with the park and the Fana landscape in the south. The main theme of The Square is water. From its source in the south, an artificial watercourse runs through the whole building and into a large pool on the entrance side. The water takes on many different shapes and connects several works of art and ornamental items on its way.

The three gardens between the finger-shaped wings are well protected from the north wind. They are different from each other, are exposed to the sun at different times of the day, but can all be used in connection with the communal areas on the ground floor.

Nerve centre

Running across The Square is what we have called *The Street*. It is one hundred metres long and six storeys high and has galleries on both sides. The Street is the nerve centre of the building and the most important communication artery. The galleries are connected to all of the building's wings and floors via glass lifts and main stairs on both sides.

The Street will give the building life: everyone who has to go somewhere in the building must pass through it. In the main building it runs into the different wings. Here we have the café and conference centre with a meeting-room section and auditorium. Coffee bars and informal meeting places are also here, furnished with café and lounge furniture.



Figur 1: The Street

Breathing space

There is very efficient use of floor-space in the office areas, and almost all work is carried out behind computer screens. There are few doors to close and one has to lower one's voice and behave in a considerate manner everywhere.

The Street and galleries will make up an airy, well-arranged and democratic space, where the building's users can meet and communicate freely and informally.

Integrated systems

The wings have no columns and are of varying widths. This contributes to the high floor-space efficiency. It is supported by concrete units in the outer walls. The units make up the covers of the vertical supply-air ducts that are integrated into the wall. The concrete surface has been expanded as much as possible and the structure provides a combination of high heat capacity and direct heat-exchange between the structures and supply/exhaust air. This concept has been previously outlined in the document drafted during the first competition, and has been developed by the project group subsequently.

The windows are high – similar to French doors – and stretch all the way to the ceiling. This conveys light very well within the premises. Everywhere emphasis has been placed on exploiting the forces of nature and its resources – in order to save energy as well as to increase the level of comfort and usability.

Optimum utilization of floor-space

Because air is transported inside the outer walls, these are quite thick (approximately 80cm). The advantage is that there is no need for internal shafts and the height of each storey could be reduced. Altogether, this significantly reduces the volume of the building. This means that, apart from being financially prudent, it has also made it possible to construct five storeys within the height specified by the building regulations.

Dividing walls consist of a partitioning system, developed specifically for this project, which makes it possible to change the layout quickly without altering permanent structures or installations.

In the office wings, the net floor-space utilization is approximately 11m^2 per workstation. All meeting rooms are situated in a communal meeting-room section of the main building.

The building's total net floor-space (excluding the car park in the basement) divided by the number of staff members is approximately 18m^2, and its gross floor-space is just under 20m^2.

Natural materials

The outer walls are covered with pale grey bricks. This type of brick gives weight and a rich colour display to the body of the buildings. The brick walls are erected right from the ground level and change into granite bricks in places where the basement walls are required.



Figure 2: Outer walls with grey brick and top floor with ochre woo

The top floor and bays have been designed to have a calming effect – made of warm ochre wood.

The modern Bergen building

The expression of the building is a combination of classic and modern. It incorporates traits from Fana district's robust wood and stone architecture and from Bergen's urban and its locality-based building culture. At the same time the building's structure and layout are clearly modern and international – characterised by high technology and the use of advanced electronic systems of control.



Figure 3: Facade

The open-plan and flexible interiors symbolise quality – strength, responsibility and innovation.

Environmental activity during the construction process

Before the construction process began, Telenor Eiendom

had an environmental handbook prepared as the basis for all project and construction work at Kokstad. This environmental handbook forms part of the terms on which contracts for advisers as well as the building contractor are based. In order to achieve the objectives stated in the environmental handbook, it was important that demands regarding environmental awareness were incorporated into the contracts and that environmental requirements were incorporated into every stage of the project.

The environmental consultants, Remba AS, have provided training to the advisory team in the form of information, distribution of literature and making presentations. As a participant at all of the project meetings, the environmental consultants have been involved in placing emphasis on energy and environmental aspects and have ensured that the other participants in the project have taken care to protect the outside environment.

The environmental consultants have produced a standard document for the environment plan that the building contractors have incorporated into their activities. The environmental plan indicates the procedures and routines that ensure that the environmental requirements are followed up and respected and that this is documented. The environmental plan includes the building owner's requirements as regards materials/products, refuse, environmental measures during the construction phase (clean construction site) and the requirement for protecting the outside environment

The environmental consultants have checked up on whether the building contractor's environmental plans were carried out as required. A standard form has also been prepared for documentation of all materials that are included in the building. This form should be completed and submitted by all building contractors that deliver equipment for the building. All product information should be stored in a common database.

Eco-building project

At the end of the building project, an eco-building project is implemented, the objective of which is to document that the environmental criteria in the planning phase result in reduced environmental strain in the form of low energy consumption and an improved internal environment in the operational phase. The project is divided into the sub-projects "Building-automation and Reduced Energy Consumption" and "Climate Installations, User Assistance and Complaint-free Indoor Climate". Detailed assessment procedures have been designed so as to document the reduced energy consumption and improved indoor climate as a result of the high degree of automation.

Flexibility

The building owner's requirements relating to flexibility of the office section of the building have imposed constraints as regards column-free office space and the same ceiling height throughout the office section. In order to satisfy this, 400 mm structures for dividing the different floors have been used. They span 16m from outer wall to outer wall.

Flexibility and the environment for HVAC and indoor climate mechanisms

Telenor Eiendom has placed heavy emphasis on having technical installations such as heating, ventilation, sanitary installations and indoor climate modelled on the basis of environmental considerations. All choices of solutions and materials should be based on a conscious environmental assessment. Telenor's operations will gradually change and after the building becomes operational it will be necessary to adjust room solutions and furnishings. The indoor climate mechanism should be as flexible as possible and should be easily adjustable to adapt to new room solutions and requirements without substantial rebuilding.

The supply of well-filtered ventilation air is automatically adapted to fit the prevailing situation.

Only in rooms with substantial heat from electronic equipment will the need arise for local supplementary cooling systems. The building has been designed so that such rooms producing significant heat, or with very special room temperature requirements, may be situated anywhere in the building.

In order to create a flexible building with efficient use of floor-space, totally new solutions have been selected for controlling the technical installations.

Energy and the environment

An environmentally sound building requires a good indoor environment with as little use of energy and pollution of the outside environment as possible.

The following energy sources, listed in order of priority, are used for heating the building:

- Internal excess heat from the IT room etc. that is recycled using the building's heat pump.
- Warm air supply from the collection of heat from the mild Western Norwegian air by the building's heat pump.
- In unusually cold periods the building can be supplied with remote-source heat from the garbage incineration plant in Rådalen.
- The building's heat pump is used in the summer to cool down the ventilation air. The system is therefore used throughout the year, and not just during a few hot days in summer.

The environmental handbook specified the standard for the building, including the energy performance standard. As an example, the energy performance standard was set at 120 kWh/m^2 per annum, and more than 40 environmental parameters was defined. After more than one year of operation the measurement program show results ofe energy use is a little bit less than 120kWh/m^2 per annum The goal will now be revised The new goal that is being discussed is 80 kWh/m^2 per annum.

Lighting

General lighting in the office sections is by suspended light fittings with upwards illumination, in order to provide dazzle-free lighting. The average lighting strength is 300 lux. There is generally no manual switching on/off of lights, as this is controlled by the Lon Works bus system. This system is automatically overridden by the fire alarm, when authorising access, and during other events that require the lights to be switched on.

The decentralised 230V illuminated signage (e.g. Exit signs) system is connected to the Lon Works bus system for controlling and monitoring.

LonWorks

LonWorks was selected for use in Telenor Eiendom's Kokstad project. The building's many technical installations – mechanisms and installations for authorising access, alarm, central electrical mains, electric power distribution, main switchboard, meeting and conference rooms, auditoria, and office sections etc., are all connected to a control network based on Echelon's technology called LonWorks – Local Operating Network.

The purpose of LonWorks technology is to provide improved monitoring of the technical installations, improved possibility to adjust the control options for energy consumption, while at the same time optimising the indoor climate, on an individual basis where possible.

A product called **"Office Node"** has been developed for the building. This product will be installed in the ceiling panels. One of the products detects whether there is anyone (movement) in the room as well as the temperature. The same product contains a so-called room regulator (3 PIO) for sequence controlling of heating/cooling/ventilation. Additionally, the Office Node contains relays for controlling the lights.

Information from and control of the several thousand nodes (intelligent products) in the solitary control network is collected in a master computer/presentation system that simultaneously receives impulses and is used for logging data/information and power consumption.

Conclusion

In a 26,000m^2 new office building housing 1,120 people for Telenor, a telecom company, in Bergen, the goal was to build a sustainable building. We were successful in accomplishing this goal. The goal was also to combine traditional building craft, extensive use of modern technology, environmentally friendly building methods and challenging decoration in the same building. At the same time the targets that were set for space efficiency (19.3m^2 per employee), energy efficiency, and indoor air quality were very high. The result so far after more than one year of operation is an annual saving of NOK 20 million (€ 2,5 million). The energy cost is 60 NOK/m^2 per annum. (120kWh/m^2 per annum) (€ 7,5 €/m^2 per annum) which is more than 50% less than average for similar office buildings in Norway's cold climate.

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Environmental management in 9 Swedish real estate companies – learning to use ISO 14001

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1. INTRODUCTION

In order to reach society's environmental objectives (Regeringen 2001) for this century, considerably reducing the environmental impact from the building sector plays an important role. In 1996, Svane conducted a study about environmental practice in 12 housing companies (Svane, 1998). Since then, a new device for handling environmental issues in companies has been introduced, the Environmental Management System (EMS). In 1997, the implementation of an EMS according to ISO 14001 in six member organisations was studied by the Swedish Association of Municipal Housing Companies (SABO, 1998:A). Since then, how has the environmental practice described by Svane (Svane, 1998) been integrated in the EMS?

The EcoEffect tool has been developed at the Royal Institute of Technology (Glaumann, 1999), as a means to calculate environmental effects caused by a real estate. One area for implementation of the tool initially stated was in internal environmental management processes of real estate companies. For this purpose, a study of environmental management in nine Swedish real estate companies has been carried out. The environmental practice has been evaluated using the structure in ISO 14001 as a conceptual model (SIS, 1996). Interviews and, to some extent, review of documents has been carried out and in this paper some preliminary findings will be presented. The emphasis lies on the ISO 14001 concepts of identifying environmental aspects, setting objectives/targets and follow up of environmental results.

2. THE STUDY

What approaches do real estate managers in Sweden apply today to deal with environmental issues? What factors are of importance to handle the issues eco-efficiently, i.e. maximise value output with minimised environmental impact? Can the EcoEffect tool contribute to improve this process? These questions formed the basis of the study. The included companies were primarily chosen because they were known to be among the most progressive concerning environmental practice in the sector. This was a precondition for getting interesting answers concerning eco-efficiency. Four of the companies are municipal housing companies, two are private companies listed on the stock market that manage premises both for housing and commercial activities. One company manages mainly premises for commercial activities and is state-owned. The municipal companies are tied to a certain municipality whilst the others are active mainly in the big city areas of Sweden. The remaining two companies are a municipal administration managing the municipality's real estates and an international company that is specialised on real estate management working for real estate owners. The companies vary in size with the biggest letting nearly twelve times the area space let by the smallest company. Three companies were certified according to the standard ISO 14001.

Primarily the environmental managers of the companies were interviewed in an open ended way, thus being able to get hold of the interviewees comprehension of aspects and still keep the interview to some predestined themes (Lantz, 1993, Kvale, 1997). In some cases, technical and operative staff has been interviewed in order to widen the view on the issues. As a complement to the interviews, internal documents concerning environmental management were reviewed. To get a structure of the study, ISO 14001 has been used as a template.

To this stage only a few dimensions of the interview material have been analysed, giving the themes for this paper. There are a lot of more dimensions that can be discussed using the material. This will be further outlined in a coming report.

3. RESULTS

3.1 Environmental management and environmental practice today

Figure 1 shows a history of four of the investigated companies environmental management practice. These four are well representing the variety of chosen strategies that has been observed in the study. The companies that have a history of environmental practice show a similar pattern. The work often started around 1995 with an environmental practice driven in projects (point 1 in the figure), mainly dealing with the issues coming up on the desk for the day. A main ingredient in these initiatives seem to have been the general rising interest for environmental issues in Sweden, driven mainly by the municipalities in terms of Agenda 21. Normally a person in the company who was concerned with the issues and had the authority to act was involved in initiating these activities.

An obvious overall conclusion is that systematic handling of environmental issues did not begin until this procedure was outlined in ISO 14001 in 1996 (SIS, 1996). The environmental practice has then gradually been incorporated in a structure that is recognised in ISO 14001. The coming sections are more in detail commenting the companies processes concerning controlling in relation to environmental objectives.

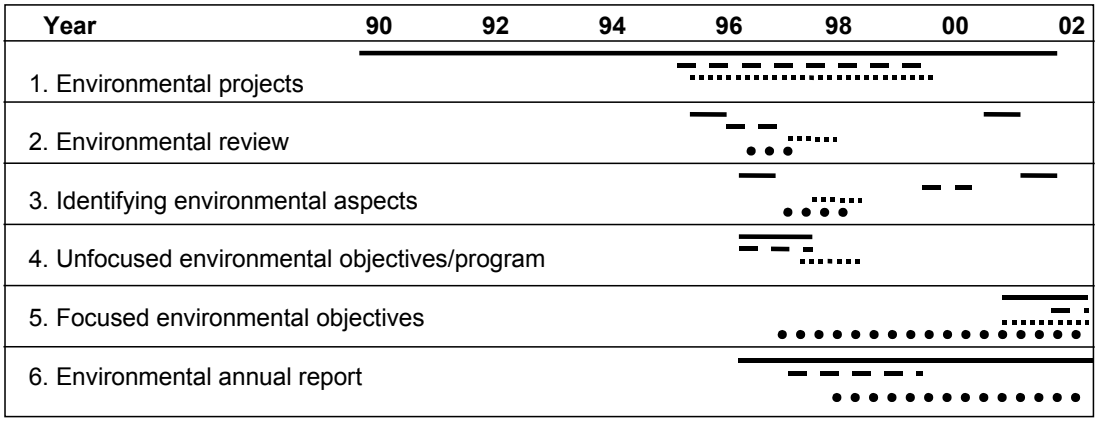

Figure 1 Characteristics of environmental management in four of the studied companies, 1= ——— 2= – – – 3= ····· 4= • • • •

3.1.1 Identifying and assessing environmental aspects. All interviewed companies have identified significant environmental aspects according to ISO 14001 and this activity is, as shown in figure 1 (point 2 and 3), commonly carried out soon after the environmental review. Table 1 shows the diversity of significant aspects in the investigated companies. Energy use

and built-in substances are examples of aspects identified as significant by many of the companies. More than half of the aspects is, however, identified only by one company. All companies use a method involving setting scores, relating the aspects to various environmental effects, e.g. emissions to air and waste production. In all cases, the person who carries out the assessment sets the scores subjectively. To a limited extent quantitative values on the aspects, such as amount of used energy, are considered in the assessment but the aspects are more seldom related to real environmental effects in a systematic way. Other driving forces, such as saving money or stakeholder demands can also play a significant role. In seven of the nine companies, the assessment methods were developed by a consultant and the environmental managers were therefore not very familiar with the method of assessment:

> "*I have not familiarised myself with this method because I considered it too confusing. At first, I read it, but I decided to make a new one, one of my own..* "

One interesting remark is that the majority of the interviewed managers were bringing up indoor environment as an important issue. Still, only one of the companies defines this as a significant environmental aspect. The same company identifies CO_2-emissions as an aspect, which involves energy use both for heating and transports. Earlier this company assessed the aspects in a similar way as the rest of the companies do today, i.e. as energy use. This can be seen as a development of the assessment. No significant differences between the companies are revealed in assessing environmental aspects, apart from the private companies extended focus on built-in environmental problems, like PCB. A reason for this can be that it is seen as a strategic issue within their business concepts, including developing the properties.

Table 1 Significant environmental aspects and areas for environmental objectives according to document review. Each letter signifies a company in the study. Only documents from five companies were available.

Environmental aspect	Companies that identifies this aspect as significant.	Companies that have an environmental objective concerning this aspect.
Built in hazardous materials and substances	A, B, C, D, E	A, C, D, E,
Use of materials	A, C, D, E	A, B, D, E
Use of energy for heating	B, C, D, E	B, C, D, E
Use of electricity	B, C, D, E	B, C, E
Waste production – from construction	A, C, E	A, B, D, E
Waste production – from customers	B, D, E	D, E
Transports in service	B, D, E	B, D, E
Hazardous waste	A, D	
CO_2- emissions to air	A	A
Indoor environment	A	A
Environmental information to customers	A	A, C, D, E
Use of chemicals	B	B
Transports to and from work	B	
Outdoor environment	B	
Purchase of services	D	D
Use of energy air conditioning	E	E
Clients with environmentally risky activities	E	E
Use of water	E	C

3.1.2 Setting environmental objectives and targets.

Figure 1 (point 4 and 5) shows that a typical procedure in the companies which had an environmental practice for some years, is that the work considering targets and measures has become more structured and focused:

> ” *if you take a look in an old environmental programme, one has not really understood what objectives really are… …I mean, the environmental programme consisted of 28 pages*”

The overall impression according to table 1 is that objectives are formulated for significant environmental aspects. However, this is not always the case. It might seem surprising, why carry out the assessment and then not integrating it in the system? One reason seems to be that one wants to follow the structure of ISO 14001, but has not yet found the appropriate way to implement it in the organisation. The assessment of environmental aspects is, for instance, viewed as too theoretical by many of the interviewed. Another reason is that routines are introduced as a way of managing significant aspects instead of relating the aspects to certain objectives. An interesting remark is that four out of nine companies have an objective concerning informing customers. Many interviewees state that they consider environmental information to tenants an important issue for being successful in the environmental practice.

There are a wide variety of formulations of objectives within the companies. Even with some years of ISO 14001, measurable targets are not a rule. Nevertheless, there are some companies that are strict in using measurable objectives and targets. The opinion that it is difficult to measure environmental performance is, however, widespread. Some prefer thus more qualitative targets that resemble a checklist of activities that can be ticked off rather than targets one can struggle towards.

3.1.3 Follow-up of environmental performance. Figure 1 (point 6) shows that making annual environmental reports is not frequently carried out. Last year, only one of the companies in the study made a separate environmental report for external distribution. Three years ago, this was done by at least three of the studied companies. Today, the environmental report is to a greater extent integrated in the annual report of the company, bringing up more or less the same issues but on fewer pages. The EMS is in the majority of the companies integrated in the rest of the business programme when it comes to follow-up. Thus, the common pattern is that operative staff is more involved in measures follow-up, executives in target achievement and the environmental manager in environmental performance follow-up.

Follow-up of environmental performance indicators is not frequently carried out except for in energy saving, such as kWh/m^2. This indicator gives us only the quantitative aspect of energy use. Indicators showing the effects on the environment (i.e. also incorporating the qualitative aspect) have, according to what I have seen in the interviewed companies, only been used in two cases. One of the companies has just introduced an objective concerning reduction of CO_2 -emissions. This is interesting but an exception in the study. Despite the fact that some of the municipal companies participated in a project a couple of years ago, the purpose of which was to develop a set of environmental performance indicators for the sector (SABO, 1998:B), they are not using the proposed ones. The interest for these issues is generally bigger among the interviewed managers who are in the top of the organisational hierarchy.

According to the interviewees, the reason why follow-up of environmental performance is not more developed is that data is scarce. In some cases, new routines have been introduced, for instance, to get hold of fuel consumption for transports, but in a majority of the companies the methods for data compilation are weakly developed. Still, one of the interviewees mentions that they do produce a large amount of data when this is asked for, in their case by the stock market (the Folksam index, 2002). This implies that the resources that have to be spent on finding data are raised only if there are strong incentives.

3.2 Environmental management in a business context

To be able to implement an EMS successfully in a company it is necessary to look upon it in a business context. Driving forces, obstacles and important factors for success are issues that thereby should be taken into account.

Apart from the overall concern for the environment in society, which seems to have been the sparkle for igniting the interviewed companies environmental practice, no external driving forces are experienced strong today. Nevertheless, for the companies listed on the stock market something that seem to be dawning is the interest of shareholders. Tenants could be a group that one would expect to pose demands on the real estate manager. The only demands that are mentioned, however, are wishes to get recycling systems for waste handling. If demand is weak, why then choose to introduce an EMS? All interviewees stress that they find the EMS to be a natural development for a more focused environmental practice. A way of working that sometimes also reinforces management processes in general in the company. But, the lack of driving forces is probably the reason why there are only a handful companies in this sector that have chosen to certify themselves according to ISO 14001.

The external demands from tenants and shareholders mentioned above can be examples of two different ingredients that the EMS must deal with to be efficient. When it comes to practical demands from tenants, today's trend of customer focus can probably be positive. The trend includes using well-educated staff employed directly by the company. This may strengthen the company's possibilities of reducing environmental impact caused by the users demands and behaviour through competent employees keen on informing tenants. On the other hand to meet external demands about environmental performance, calls for methods for compiling and assessing data about the company's environmental performance.

From the point of view of the environmental manager, organisational matters are stressed as important for the EMS to be efficient. Especially three aspects are mentioned; 1) the willingness of executives, 2) budget and authority of the environmental manager and 3) existing communication patterns in the organisation that support the EMS, especially concerning routines and integrating the environmental programme in the rest of the business programme. If this is not the case, the operative environmental practice is complicated and the status of the environmental issues runs the risk of becoming debilitated. The most dominant obstacle for successful environmental practice in the company mentioned by the interviewed managers is the increasingly strained organisations:

> *"Thus, the most difficult part is the hard work to get the environmental message spread in the organisation. That everyone just feels "no, no, not any more, we cannot cope with any more"*

Other obstacles mentioned are when environmental measures or targets conflict with profit or quality of indoor environment. However, the results indicate that employees, on all levels, who have a basic competence and are well informed on environmental issues, do not experience these conflicts as strong. Related to this, lack of knowledge about environmental issues is a difficulty stressed by at least half of the interviewees. How to act, to know what decision is the best in environmental terms and to be updated on laws and regulations, is considered as difficult.

4. DISCUSSION

The results indicate that we may consider the introduction of the EMS as a process. If, for instance, an environmental review is made as a starting point for a company's environmental

practice, a lot of urging problems or aspects to deal with will be revealed. An EMS according to the ISO 14001-standard focusing on a few objectives can then be experienced as a blunt tool in such an early phase of the process. When the organisation later starts to define continuous improvement (SIS, 1996), measurable and focused objectives are advancing. If so, this will lead to a need for performance indicators as a means of follow-up and comparison that can be communicated both internally and externally. If the incentives exist, gathering data needed for follow-up does not seem to be a big problem. But, executives' environmental commitment resulting in resources for the environmental manager is a main issue if the company is going to reach this phase of the EMS process. This leads us to one of the initial questions of the study. The study was carried out to answer if and in such a case how the EcoEffect tool might be used in an EMS in a real estate company. The results suggests that it is very important how and by whom it is used. The companies in the study are still in a beginner's phase concerning EMS, when a tool like EcoEffect hardly is demanded for. Further in the EMS process there are some areas where the tool, if developed, might be an aid. It may concern assessing environmental aspects, relating environmental targets to company activities, give proposals of environmental objectives and follow up environmental performance. To increase the knowledge about the environmental impact of the company's activities is essential for the environmental practice to be successful. EcoEffect may also have a pedagogic value in this process. These are issues that will be dealt with further in this research project.

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The use of Eco-design tools in Skanska

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1. INTRODUCTION

Skanska's business priorities are construction-related services and project development, with the mission to develop, build and service the physical environment for living, working and traveling. Today, Skanska operates in more than 60 countries around the world, and the number of employees amounts to about 85,000 (for further information, see our external web-site, www.skanska.com).

In early spring 2002, Skanska launched a Code of Conduct in which some key underpinnings for our performance were defined. For example, it was stated that "*we are committed to preventing and continually minimizing adverse environmental impact and to conserving resources"*. This requires that we combine all the available information on the environmental impact of our products. Tools that support eco-design are helpful in this process, and many such tools are available today.

During 2001, a number of internal *Best Practice Groups*, BPG, were entrusted with identifying best practices in various fields of the environmental management systems within Skanska. One of the additional areas that are now being examined is tools for supporting eco-design of buildings. To prepare the ground for a BPG on Eco-design tools, a study was conducted in 2001. This paper summarizes the findings of that study.

2. OBJECTIVES, SCOPE AND METHOD

The objectives of this study were to investigate which Eco-design tools have been applied within Skanska so far, to find out what was the experience of this use, and outline further work for the new BPG on Eco-design tools.

Tools were addressed that are already available on the market, have been used within Skanska and are widely accepted within the construction sector. The whole Skanska group was included in the study, however, it was found that Denmark, Finland, Norway, Sweden, UK, and USA were the countries where Eco-design tools have been most applied.

Information was acquired through the environmental network, i.e. the environmental managers at Skanska's Business Units. These provided information on what tools are or have been applied and in which projects. A number of projects were identified where Eco-design tools had been used, and those responsible for this use at Skanska were contacted and interviewed through on-site interviews, telephone interviews or e-mails. A questionnaire was used to get adequate information. Also, some of the owners of the Eco-design tools were contacted.

3. USE OF ECO-DESIGN TOOLS

Based on the findings, it was defined which ones of the tools available today are applicable in Skanska projects and in which way they are helpful. Use of three main types of tools was identified, here defined as:

- LCA-based software
- Assessment tools
- Classification/rating tools

LCA-based software

LCA-based software here refers to software for selection of materials/constructions at the early design phase, i.e. *Ecometer, BEAT 2000, BEES,* and *ENVEST*. These tools contain LCA data sets for generalized materials and constructions, and the results are ”multi-dimensional” in the sense that they do not rate the environmental performance of the building. The most frequently applied tool was *Ecometer*, developed by Skanska Finland in co-operation with VTT (start in 1997, launched in 2000). At the time of the study, Ecometer had been applied in 79 new residential projects.

Assessment tools

Assessment tools are here defined as comprehensive lists of criteria assessing the environmental performance of a building. As a rule, the criteria are divided into categories that are divided into sub-categories, each to which belong a number of criteria. The total number of criteria may amount to 80-90. Each criterion may in its turn be assessed through 3-5 level scales. Some examples of assessment tools are *Environmental Status of Buildings, Eco-profile,* and *EcoEffect*. An advantage with this type of tools is that all desired issues may be addressed at the same time. At Skanska, the most frequently applied assessment tool was *Environmental Status of Buildings*, developed by approx. 10 Swedish real estate owners, including Skanska (start in 1995, launched in 1997). At the time of this study, 76 commercial buildings had been assessed at Skanska. The assessment may only be made by trained inspectors and Skanska held around 10 own such inspectors.

Classification/rating tools

In this context, classification/rating tools are defined as tools based on criteria lists that provide various types of “ecopoints” or credits. Like for the assessment tools, the criteria are divided into categories and sub-categories. The total number of points is then used to rate the building according to pre-defined levels. Hence, the tools function to benchmark the environmental performance of a building. Examples of this type of tools applied at Skanska were *LEED* and *BREEAM*. For example, *LEED* was applied at the MIT Stata Center in Boston, at the request of the client. *LEED* was developed by US Green Building Council, USGBC (start in 1995, launched in 2000).

4. RESULTS

In total, almost 200 projects were identified in which Eco-design tools had been used (Table 1). LCA-based software was the type of tool most frequently used, whereas use of rating/classification tools was less frequent. There are probably more projects to be found than these, as there are no internal procedures to compile this information. The two tools that had been applied to a greater extent (*Ecometer* and *Environmental Status*) are entirely or partly developed by Skanska. The main use of Eco-design tools had occurred during the last two years, and for several of the projects found this work was still on-going.

Table 1 The use of Eco-design tools in Skanska construction projects. Based on information from the environmental managers (2001).

Eco-design tool	Use in Skanska*	Country	LCA-based software	Assess-ment tools	Rating/ classific-ation tools
BEAT 2000 www.by-og-byg.dk/english/publishing/software/beat2001/	**A**	Denmark	**X**		
BREEAM http://products.bre.co.uk/breeam/breeam1.html	**C**	England			**X**
EcoEffect www.bmg.kth.se/Bob/EcoEffect/	**A**	Sweden	**X**	**X**	
Ecometer www.skanska.com (Environment/Projects)	**D**	Finland	**X**		
Eco-profile www.byggforsk.no/oekoprofil/	**A, B**	Norway		**X**	
ENVEST www.bre.co.uk/service.jsp?id=52	**B**	England	**X**		
Environmental Status of Buildings www.miljostatus.com/	**D**	Sweden		**X**	
LEED www.usgbc.org	**B**	USA			**X**

* A = Participation in testing, B = Occasional use (1-3 projects), C = Moderate use (5-15 projects), D = Frequent use (>75 projects)

In addition, a number of projects were identified where related tools had been applied, primarily for design of energy efficient buildings or to create a healthy indoor climate. Some of these tools had been developed internally at Skanska. During 2002, Skanska will participate in the testing of GBTool in 2-3 projects, but this work had not started at the time of the study.

Motives for use

The following main motives for use of Eco-design tools were identified:

- A need for common definition(s) of a ”green” building
- To meet client demands; Eco-design tools may be a prerequisite for acquisition
- Product information – a service to the client
- A help for communication and decision-making at the early design stage
- Improvement analysis for existing buildings; basis for decision-making in Facilities Management
- Facilitates setting and follow-up of targets in our Environmental Management Systems
- To avoid risks
- To meet (future) policy statements and political goals
- A means to work beyond legislation/rules; positive labeling
- Pedagogic tool in our own environmental training
- Marketing / Competition
- Prepare for future external demands (i.e., application of LCA-based tools in European technical specifications for construction products)

Obviously, there are various reasons for using Eco-design tools, and the project stages differ at which the tools are applied. According to the interviewees, the most prominent motives were client demands, setting and follow-up of our environmental targets, and help for

communication and decision-making at the early design stage. It was regarded useful for Skanska to participate in the development and testing of new tools, as we may then affect the design of the tool. The motives for using the tools were not always explicit; sometimes it was considered our duty as a large building contractor to participate in this kind of development projects and offer opportunities to test Eco-design tools through case studies.

Experience

Some main advantages and disadvantages of using Eco-design tools were identified (Table 2). The learning experience and improved understanding of environmental issues was often emphasized, although this was seldom the primary motive for applying the tool. Wide acceptance and use of a tool was considered important, and it could be seen that it takes at least 4-5 years to develop a new tool and establish it on the market.

Table 2 Advantages and disadvantages of using Eco-design tools. Based on experience made in Skanska projects (2001).

Advantages	Disadvantages
➢ Helps to clarify what is environmentally sound; takes a standpoint ➢ Helps inexperienced clients raise environmental demands ➢ Has raised the environmental awareness among employees ➢ Publicity and good-will	➢ The effects are not always the ones desired; sometimes more assessment than basis for decision-making ➢ It is time-consuming to learn how to use the tools ➢ All tools are not user-friendly; some are considered too academic

Time and costs

Many regarded application of Eco-design tools as too costly; this seemed to be a common opinion also among those that had not themselves tested such tools. However, this is not always the case. For example, download of criteria lists and demos is often free. Then there are some non-recurrent fees, such as (examples of costs within brackets):

- LCA-based software ($ 100 - 1 300)
- Training and/or examination of inspectors ($ 300)

These costs may be easily motivated when a tool is used repeatedly. Then some recurrent costs occur for every project, mostly arising from the time needed to do the assessment, such as (examples of time or costs within brackets):

- Data gathering (1 day - 1 month)
- Calculations (1h - 1 day)
- On-site inspections (3 days)
- Registration/Certification ($ 350 -2 000)

Not all the costs listed above occur for all tools. It should be noted that the costs for software etc. vary depending on the user; for example, there are sometimes different prices for companies and academic users. Some rough estimates of total cost and/or time needed for application of Eco-design tools are shown in Table 3. The wages for those applying the tool in the project have not been included. Both non-recurrent and recurrent costs have then been taken into account.

Table 3 Total cost and time needed for application of Eco-design tools in a construction project (examples, 2001).

Type of tool	Cost*	Time
LCA-based software	$ 100 -1 300	1 day - 1 week
Assessment tools	$ 2 000 – 2 500	1 week - 2 months
Classification/rating tools	$ 2 000	4-5 weeks

* Including software, registration/certification etc. Excluding the cost for the time spent on data gathering, calculations, etc.

A common experience was that the time spent on data gathering and assessment etc. is the most considerable cost. For internal tools like Ecometer, the only cost is the time needed for data gathering and calculations. Naturally, the time needed depends largely on which data have already been compiled for other purposes, which implies that the tools should preferably be based on data that are needed also in other contexts. Use of LCA-based software seemed to require less time and lower costs than use of the other types of tools, presumably because the software generally contains data sets and much of the project specific data used has already been compiled for other purposes.

5. CONCLUSIONS AND DISCUSSION

It was found that Eco-design tools may be helpful in Skanska's work to improve the environmental performance of buildings. There is so far no wide-spread experience at Skanska of using such tools, although a number of tools have been tested and a few are applied on a broader scale. There were various motives for the use, including client demands, setting and follow-up of our environmental targets, and help for communication and decision-making at the early design stage. To be prepared for future client requirements etc., we need more knowledge of the tools that dominate the market today. There is also an expressed need for simplified tools that characterize a building's environmental performance. Suggestions for further work in the Skanska BPG on Eco-design tools are:

- Continuous group-wide sharing of experience
- Continuous testing of the most prominent Eco-design tools, so that we have basic knowledge of the application when needed in future projects
- Propose an increased use of Eco-design tools as a means to set targets in our Environmental Management Systems
- Participate in developing and testing of new tools
- Training of inspectors, so that application of Eco-design tools may become a business opportunity
- Setting up an internal platform on our Intranet with descriptions of relevant Eco-design tools, projects where the tools have been applied, contact persons at Skanska, websites etc.

The BPG will continue to follow up which Eco-design tools are applied in Skanska and what is the gained experience. The need of a simplified “base-line tool” for use in Skanska projects world-wide will be further explored.

ACKNOWLEDGEMENTS

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Potential, Limitations and Sustainability of Autoclaved Aerated Concrete (AAC)

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1. INTRODUCTION

The sustainability of construction materials and products continues to be a hotly discussed topic in Italy. For a product to succeed in a highly regulated market, in fact, it must be capable of responding to the pressures exerted by the complex technical, social and economic system from which our efforts to change our surroundings spring, and which motivates us to transform and recover the buildings around us.

For the technologies used for the building envelope in particular, a tendency to choose products chiefly on the basis of their energy-saving properties began to loose ground in the 1990s, when attention shifted to ecologically compatible products, i.e., those which have a low environmental impact, are economically competitive, and involve innovative processes.

Process innovation is not restricted solely to manufacturing, but involves an integrated approach which sees the product as part of a whole system of relationships that come into being during its life cycle, and thus attempts to ensure that these relationships can unfold more smoothly.

Though this systems-oriented approach translates, for example, into a greater attention to maintenance conditions and to recycling salvaged materials, it also means greater flexibility through products that can be adapted to changing design and service conditions. Finally, it means that design criteria will include dimensional coordination, integrated utilities, and "clean", well-organized construction sites.

This paper discusses an on-going study carried out as part of a research program dealing with the sustainability of certain building envelope technologies now under way at the Politecnico di Torino Department of Construction and Territorial System Engineering. Consequently, the study addresses the sustainability of load-bearing autoclaved aerated concrete wall construction units.

2. METHODOLOGY

Autoclaved aerated concrete (AAC) is produced from extremely fine silica-base materials such as cement, lime and other hydraulic binders which are mixed with water to form a slurry. Reagents are then added which trigger a chemical reaction, generating gas which forms minute air cells in the slurry. Additives can also be used to improve the consistency and quality of the finished product. After the mixture has set in special molds, the mass is cut into

the desired formats. The products are then steam cured under pressure in autoclaves, where they are chemically and dimensionally stabilized.

In order to assess several characteristics and properties of this material, three commercial brands of autoclaved aerated concrete blocks for load-bearing wall construction were investigated. These three brands, all of which are readily available on the Italian market, will be designated below as A, B and C. For each brand, ten blocks were sampled from pallets taken from different lots. These blocks were analyzed and then used to prepare three test specimens.

Block morphology was evaluated first. Specifically, blocks were assessed as regards color, prism configuration, face flatness, edge straightness, presence of cracks, protuberances and chipping, and deviations from stated nominal dimensions[1].

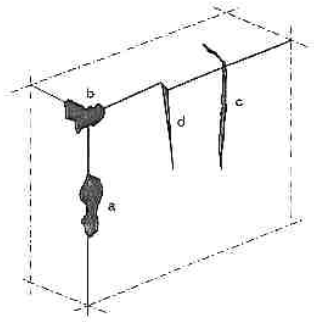

Figure 1 *a) Edge chipping; b) Corner chipping; c) Deviation from flatness; d) Surface discontinuity*

Type A blocks were a uniform off-white with a minimum of gray specks. As regards appearance, type A blocks were free from edge chipping[2], corner chipping[3], deviations from flatness, surface discontinuities and cracks. An important morphological feature of these blocks is the presence of lifting grips located along the short sides of the block. Dimensional tolerances on block length, height and thickness complied with the maximum deviations specified in UNI U32.10.241.2 "Autoclaved aerated concrete units for masonry – Acceptance criteria"[4].



Figure 2 Block A, the lifting grips

Type B blocks were a fairly intense gray. Color was uneven, with a number of dark gray specks. As regards appearance, type B blocks exhibited several edge chips, corner chips, deviations from flatness and surface discontinuities, which were measured with a gauge and straightedge[5]. All sides of the blocks are smooth, with no lifting grips. As for the previous type, dimensional tolerances on length, height and thickness of type B blocks complied with the maximum deviations specified in UNI U32.10.241.2 "Autoclaved aerated concrete units for masonry – Acceptance criteria"[6].



Figure 3 Block B and block C

Type C blocks were an uneven dark gray with a number of black specks. As regards appearance, type C blocks exhibited numerous edge chips, corner chips, deviations from flatness and surface discontinuities, which were measured with a gauge and straightedge. All sides of the blocks were smooth, with no lifting grips. Measured deviations for block length, height and thickness were ± 0.7 mm.

In the second stage of the study, laboratory tests were carried out in order to investigate the blocks' chemical composition, density, capillary absorption and freeze-thaw resistance.
Atomic absorption spectrophotometry and wet method chemical analysis were used to determine the percentage by weight of the various components.
The specimens prepared from three representative blocks showed substantial differences in the percentages of soluble silica, calcium oxide, aluminum oxide and sulfur trioxide (SO_3)[7]. Density also showed significant differences, ranging from 0.554 to 0.665 kg/dm^3.

In tests for dimensional stability, capillary absorption and freeze-thaw resistance[8], type C blocks showed significant deterioration and spalling, with the corners crumbling to the extent that they broke away completely.
This weakness on the part of the type C block is linked to its porosity as indicated through the microscopic test. While type A and B blocks have pores measuring 0.5 to 2 mm in diameter and a few 3 mm macro-pores, type C blocks have pore diameters between 0.6 and 0.9 mm and a few 2 mm macro-pores. In addition, the majority of the cells are closed.

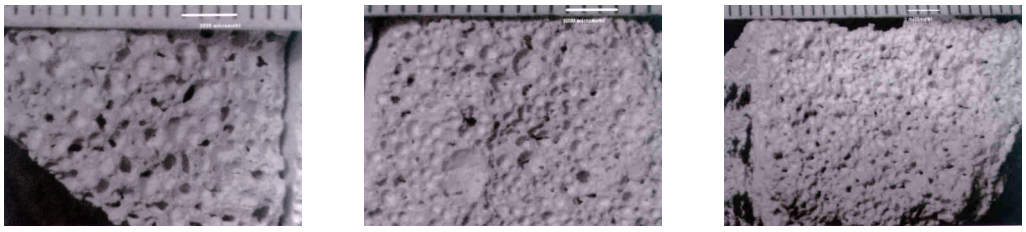

Figure 4 Microscopic comparison of specimens A, B and C

The third part of the investigation addressed the following assessment parameters: manufacturing process, transport, installation, durability and maintainability.

In assessing the product manufacturing process[9], it was found that type A and B blocks are produced in technologically advanced facilities, where current environmental protection regulations are followed and particular attention is devoted to recovery of processing waste, sludge, and atmospheric emissions of vapors and other substances. By contrast, the production facility for type C blocks is marginally compliant with current requirements, and no special attention is given to environmental concerns.

As for transport, the three types of block are shipped by rail to some extent, though road transport – which has a higher environmental impact – predominates.
Direct shipments are made to all parts of Italy, with no appreciable differences between the three brands.
For indirect sales through dealers and retailers, type B blocks have a higher geographic penetration than the other two types, largely because this manufacturer has a larger number of production facilities which are more widely distributed across the country. For this reason, consignments of type B blocks can be made much more quickly for both direct factory sales and retail sales, with an average of around 1 or 2 days between the time of order and delivery to the construction site. By contrast, average delivery times are around 15 to 30 days for type A blocks, and some 10 to 15 days for type C blocks.

As regards on-site storage, the same considerations apply to all three types: blocks are palletized and protected with shrink-wrap plastic, and must be stored in a dry area under cover, raised off the ground by means of wooden blocks or the like, and protected from the elements with water-repellant tarps.

These storage instructions also apply to handling during installation. Type A blocks show decided advantages at the time of erection, as they are provided with lifting grips which make them easier to handle and also ensure healthier conditions for workers. In addition, type A blocks ensure more precise, accurate construction because of their minimal dimensional variations.

As regards durability and maintainability, studies are still under way in a number of European Union member states and in Sweden[10], where this material has been used for over 60 years. Nevertheless, it is already clear that autoclaved aerated concrete blocks, which are produced through an industrial process that results in a certain homogeneity and uniformity, have a high degree of chemical stability which ensures a good level of durability. However, the presence of micro- and macro-pores causes a certain permeability to liquids, which can lead to partial destruction of the matrix through dissolution. In addition, AAC is easily damaged by acids, acid salt solutions and acid vapors. The amount of destruction depends on acid concentration, temperature and relative humidity[11]. Consequently, this material must be protected with plaster or cladding of various kinds (e.g., brick, tufa blocks, wood siding, clapboard, ceramic tiles, etc.) to guarantee durability. Maintenance carried out on the coating or cladding used to protect the AAC serves entirely to keep the cover material in good condition, and is not influenced by the differences in the characteristics of the three types of block.

3. CONCLUSIONS

In order to compare the analysis results obtained for the three types of AAC block, an IT tool (simplified LCA) is now being developed. This tool will be used to evaluate block parameters and thus formulate sustainability ratings which can help designers and construction contractors in making decisions.

It is precisely the latter group who, together with the end users of buildings constructed with AAC, will be the major market drivers in improving environmental quality and bringing down the overall cost of this material's technology. Indeed, as Felix Guattari wrote in "The three ideologies", "… ecology [though the same applies by extension to sustainability in construction] has three dimensions, each of which is meaningless without the others: the first dimension is social, as it is important that people can express and contribute to the decisions

that involve them; the second is psychological, and concerns the relationships that each of us has with the surrounding world. It is only then that we come to the third, or technical and operative, dimension …".

And it is in this sense that the debate in the world of architecture is permeated by signs of a keen interest in sustainability, and it is no accident that designers of enormous prestige are striving to find new means of expression such as those discussed by way of example below.

In recent years, the interest shown by many renowned designers in purely 'ideological' questions has plummeted, giving way to a freer spirit of experimentation founded on a greater regard for concreteness and a new attitude towards materials and the environment. This has wrought profound changes in the relationship between architectural and technical concerns, which is now more open, more fluid, more diversified. In this connection, we provide two examples: a conversion project and a new construction where AAC was used with particular attention to the issues discussed above.

4. CASE STUDIES

4.1 The School of Engineering building in Brescia

The first case study is the new site of the School of Engineering in Brescia, with a surface area of 32,700 m^2. The design by Prof. Silvano Tintori employs a modular grid layout which promotes flexibility. This is a major advantage in a university setting, as spaces can be readily adapted to the users' varying needs. The use of lightweight AAC blocks provided significant design advantages, optimizing acoustic and thermal insulation.



Figure 5 View of the School of Engineering building in Brescia, designed by Silvano Tintori

4.2 Pavilion at the '92 Columbus International Exposition in Genoa

An original interpretation of the material's use, on the formal level as well as in terms of technology and sustainability, was provided by Renzo Piano with his design for a curtain wall on the large facades of the Pavilion for the Columbus International Exhibition. Brick panels were installed without mortar on a steel frame structure supported by an AAC block wall.



Figure 6 View of the Columbus International Exposition Pavilion by Renzo Piano

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[1] Draft standard UNI U32.10.241.2 "Autoclaved aerated concrete units for masonry – Acceptance criteria" specifies maximum deviations of ± 3 mm for length, ± 1.5 mm for height, and ± 2 mm for thickness.

[2] Draft standard UNI U32.10.241.1 "Autoclaved aerated concrete units for masonry – Generalities" defines edge chipping as loss of material along an edge of the unit.

[3] Draft standard UNI U32.10.241.1 "Autoclaved aerated concrete units for masonry – Generalities" defines corner chipping as loss of material at an angular point of the element.

[4] Procedures for determining tolerances complied with the protocol outlined in UNI U32.10.241.3 Test methods.

[5] Procedures for determining chipping, flatness, discontinuities and cracking complied with the protocol outlined in UNI U32.10.241.3 Test methods.

[6] Procedures for determining tolerances complied with the protocol outlined in UNI U32.10.241.3 Test methods.

[7] These tests were carried out in accordance with the protocol outlined in RILEM RECOMMENDED PRACTICE. *Autoclaved Aerated Concrete, Properties, Testing and Design,* Rilem Technical Committees 78-MCA and 51-ALC, edited by S. Aroni, G.J. de Groot, M.J. Robinson, G. Svanholm, F.H. Wittman. (1993), printed by E & FN SPON, London, Great Britain, pp 12 to 31, and in accordance with UNI U32.10.241.2 3 Test methods, pp. 7 to 8, 14 to 15.

[8] These tests were carried out in accordance with the protocol outlined in UNI U32.10.241.3 Test methods, pp.14 to 15.

[9] A site review was carried out at each plant, compiling a manufacturing process assessment form.

[10] E. Bohner, K. Odeen. (1999). Durability of Building Materials & Components – Service Life and Asset Management, *Durability of Autoclaved Aerated Concrete,* 8 dbmc, Vancouver, Canada, pp.107 to 117.

[11] S. Aroni, G.J. de Groot, M.J. Robinson, G. Svanholm, F.H. Wittman. (1993). RILEM RECOMMENDED PRACTICE. *Autoclaved Aerated Concrete, Properties, Testing and Design,* Rilem Technical Committees 78-MCA and 51-ALC, printed by E & FN SPON, Great Britain, pp. 32.

Eco-efficiency of Commercial Property

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1. INTRODUCTION

Eco-efficiency can be defined with help of the value of the products or services that a company produces and the environmental pressures that are caused from the production (OECD 1998).

$$\text{Eco-efficiency} = \frac{\text{Value of products or services}}{\text{Environmental pressures}}$$

The definition of eco-efficiency was applied in the Finnish REKOS research project (Häkkinen et al. 2002) regarding real property business and building trade. Performance and conformity of the real property and building replaced the original value of products or services.

$$\text{Eco-efficiency} = \frac{\text{Performance and Conformity}}{\text{Environmental pressures}}$$

A general outline of eco-efficiency for real property owners and developers was created in the REKOS research project and it was applied to the outline that was developed for Kesko Oyj. Kesko Oyj is the leading trading company in Finland and it owns and plans most of the commercial properties it uses.

2. SCOPE

The aim of the case study in the REKOS research project was to create for Kesko Oyj
- an application of the developed general eco-efficiency outline, and
- a model of environmental declaration for commercial properties.

The eco-efficiency outline and environmental declaration should be easy to use but they should include the most essential aspects at the same time.

3. OUTLINE FOR ECO-EFFICIENCY

The eco-efficiency outline includes a list of such essential actions that guarantee the eco-efficient action of the organization owning and planning real properties if fulfilled. The outline helps to plan and build an eco-efficient property and to maintain it. The eco-efficiency outline for Kesko Oyj is described in Table 1.

Table 1 The eco-efficiency outline for owning and planning commercial properties.

1	The recognition of environmental aspects, setting objectives and targets and continual improvement of own action regarding planning
1.1	To acquire and use methods, criteria, classification and tools for recognition
1.2	To specify and develop systematically the planning process
1.3	To set measurable or otherwise verifiable environmental objects and targets for acquiring a building lot or trading center regarding location and engagement to infrastructure
1.4	To assess the competence of the developer in environmental issues
1.5	To plan the use and maintenance of the commercial property
2	The recognition, verification and development of appropriate performance and conformity aspects regarding planning
2.1.	To recognize and classify the appropriate performance and conformance aspects of building lot and building
2.2	To create or acquire tools to control performance and conformance
2.3	To set requirements for performance and conformance of different types of projects and commercial property
2.4	To verify that the requirements set for performance and conformance are fulfilled
2.5	To continually develop the own requirement systems
2.6	To continually develop the level of requirements continually

Examples of environmental aspects regarding the planning of trading centres are:

- traffic connections to the lot
  - passenger car traffic
  - freight traffic
  - public transportation (buses, local trains and underground)
  - bicycle and pedestrian traffic
- the changes in the district traffic from the use of commercial property
- connections to public utility services
  - heat, electricity, water and sewage
- the change in use of the lot
  - dust, noise and vibration
- changes in natural conditions
  - level of groundwater and micro-climate
- possible environmental risks caused by an earlier action on the lot
  - polluted ground and groundwater
- environmental risks regarding planned action
  - risks in the commercial property
  - risks from the commercial property services
  - external risks

- environmental risks from the changes in the purpose of use of commercial property
  - demolition work
  - new action.

3. ENVIRONMENTAL DECLARATION OF THE COMMERCIAL PROPERTY

Performance, conformance and environmental aspects are described with the help of indicators which are figures or simple signs. Each aspect belongs to one of the three usual classes according to its indicator. The property owner and developer have the main responsibility for setting the criteria for class boundaries. They also set the requirements for indicators and improvement of planning methods. The internal and external changes in the building during the life cycle are taken into account by the indicators. Indicators also cover the operational period of the commercial property.

The performance, conformance and environmental aspects and their classes are gathered in an environmental declaration for each commercial property. The required performance and conformance part includes indicators for location, site and building. The environmental pressures are in a separate part and they include the most essential environmental aspects for commercial properties. An environmental declaration for commercial property is shown in Figure 1. This includes the main level of performance and conformance and environmental aspects.

The aspects in the environmental declaration include sub-levels which may differ from each others according to the type of commercial property. At least the class boundaries are usually different. Examples of sub-levels with detected classes are shown in Figures 2 and 3. The other aspects have corresponding sub-levels.

An environmental declaration can be utilized in planning commercial property renovation in addition to planning of new construction production. Renovation may include changes in purpose of use.

An environmental declaration enables comparisons of different buildings and commercial properties. However this was not the original purpose of the environmental declaration. Comparisons may provide use of valuation between different aspects. One valuation tool was applied in the REKOS research project. The tool was based on system analysis and was noticed feasible. Different geographic locations, weather conditions, opening hours and amount of clients should be noticed in the comparisons. The indicators should be normalized if exact comparisons are desired.

ENVIRONMENTAL DECLARATION OF COMMERCIAL PROPERTY

Identification data for the environmental declaration

Code of the environmental declaration
Author
Date

Description of commercial property

Name of the commercial property
Degree of preparedness
Purpose of use
Volume and area of the building (m^3, m^2)
Amount of clients (estimated)

Location and lot

Accessibility by public and light transport
Accession to supply of services of the region
Accession to the cultural and historical quality of the region
Visual quality
Integration to the neighbouring real properties
Usability

Building

Planned service life
Indoor air
Lighting
Adaptability
Usability

Environmental pressures

Survival of natural conditions and biodiversity
Consumption of material resources (tons per m^2, m^3. Non-renewable and renewable)
Consumption of electricity (MWh per m^2, m^3, client and year)
Consumption of heat (MWh per m^2, m^3, client and year)
Consumption of water (l per m^2, m^3, client and year)
Emissions from generation of electricity and heat (tons CO_2 eq. per m^2, m^3 and year)

Figure 1 Environmental declaration for commercial property.

Building

Planned service life	
- load bearing and fixed structures of the envelope	class B
- renewable building elements (for example cladding of the envelope)	class B
- surface mountings (interior linings, windows, doors)	class B
- heat generation systems (heat exchangers, boilers, oil tanks)	class A
- heat distribution systems based on water circulation (steel pipe system and radiators)	class A
- heat transfer parts of ventilation units	class B
Indoor air	
- temperature	class B
- surface temperature of the floor	class A
- allowed temporary temperature deviation from the set value	class A
- vertical temperature difference	class B
- air velocity	class B
- relative humidity air	class A
- CO_2-content	class A
- particle content	class B
- noise level from heating and ventilation units	class A
Lighting	
- illuminance	class A
- contrast rendering	class A
Adaptability	
Planning	
- alternatives for the first user	class A
- alternatives for later users	class A
- adaptability of use	class A
Use	
- adaptability of room size	class A
- adaptability of use of room	class A
Modular systems	
- frame	class A
- intermediate floor	class B
- facade	class B
Ducting systems	
- vertical	class B
- horizontal	class B

Figure 2 An example of sub-level aspects in an environmental declaration.

Environmental pressures	
Consumption of material resources	
- load bearing and fixed structures of the envelope	class B
- renewable building elements (for example cladding of the envelope)	class B
- surface mountings (interior linings, windows, doors)	class C
- heat generation systems (heat exchangers, boilers, oil tanks)	class C
- heat distribution systems based on water circulation (steel pipe system and radiators)	class B
- heat transfer parts of ventilation units	class B
Consumption of electricity	
- total consumption	class B
- consumption of commercial property (without consumption of storekeeper)	class A
Consumption of heat	class B
Consumption of water	class A
Emissions from generation of electricity and heat as CO_2-equivalent	
- total emission from generation of electricity	class B
- emission from commercial property (without consumption of storekeeper)	class B
- total emission from generation of heat	class B

Figure 3 An example of sub-level aspects in an environmental declaration.

5. CONCLUSIONS

The benefits of the created method and outline are the possibility to ensure the eco-efficiency of commercial properties and to make a profit in the long-term. Comparison of eco-efficiency of different commercial properties is possible during the project planning phase and operational period. In addition, the environmental declarations can be used for informative purposes by different stakeholders, for example planning authorities can use them to assess alternative plans.

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Environmental Impact and Life Cycle Assessment of Heating Systems

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1. INTRODUCTION

Sustainability has become a global issue by increasing awareness that there are limits to the availability of non-renewable resources and that there are limits to the nature's ability to adsorb wastes. On the other hand, energy is a key element of the interactions between nature and society, as well as a measure for economic development. There is no source of energy which is neutral with respect to the environment. Energy has an interdisciplinary nature, covering sustainable development and environmental impact. Environmental inputs to energy production and transformation should be accounted for since the environment provides free necessary inputs for energy production systems and sinks for emissions. Both parameters need to be accounted for if sustainability of energy sources and production technologies are to be evaluated and compared. Sustainability of energy sources is difficult to measure and is often valuated in a qualitative manner. Some energy sources, e.g. biomass, are attractive because it is assumed that they utilize renewable energy. However, when net energy evaluations are incorporated, it is quite apparent that biomass in most cases is not sustainable and the fuels involved in process of growing and converting biomass to a fuel give higher net energy. Clearly, the judgements of sustainability must include net energy, environmental loading and production emissions.

Life-cycle analysis (LCA) has become one of the most actively considered techniques for the study and analysis of strategies to meet environmental challenges. The strengths of LCAs derive from their roots in traditional engineering and process analysis. Also vital is the technique's recognition that the consequences of changes in technological undertakings may extend far beyond the immediate, or local, environment. A technological process or a change in process can produce a range of consequences whose impacts can only be perceived when the entire range is taken into consideration. The steps in LCA have been standardised and include goal definitions and scope, inventory analysis and impact assessment of a broad variety of emissions. Life cycle impact assessment (LCIA) involves classification of the emissions into various impact categories such as abiotic depletion potential, energy depletion potential, human toxicity, eco-toxicity, etc. Different emissions are converted into equivalents of selected reference substances such as equivalents of CO_2 for global warming and equivalents of SO_2 for acidification. The quantified contribution in the each impact category is normalised by the size of the local or global problem.

2. LIFE CYCLE ASSESSMENT AND ECO-INDICATOR METHODOLOGY

Life cycle assessment is defined by ISO 14 series standards (e.g. ISO 14040:1997, ISO 14041:1998). They do not, however, give all the necessary information required for carrying out an LCA. The main phases of LCA are goal and scope definition, inventory, impact assessment and interpretation. The various applications of LCA are not regulated by the

standard. The implementation of environmental assessment tools is complicated at all levels. It must, nevertheless, be an essential part of all the process, since every product impacts on the environment to some extent. Raw materials have to be extracted, the product has to be manufactured, distributed and packaged and ultimately it must be disposed of. If we wish to assess a product's environmental impact, all its life cycle phases must therefore be studied. A life cycle assessment can be used in two ways. First, to determine the total environmental impact of products or design alternatives with the aim of comparing them. For a designer an LCA can provide a solution if he has to choose between design alternatives or between different components or materials. Second, to determine the most important causes of one product's environmental impact and a designer can then concentrate on these to achieve improvements here first. A designer using a LCA in the design process has been faced by two major problems. The result of LCA is difficult to interpret. Within a life cycle assessment it is possible to determine the contribution of a product life cycle to the greenhouse effect, acidification and other environmental problems, while the total environmental impact remains unknown. The reason is the lack of mutual weighting of the environmental effects. In general, the careful collection of all the environmental data in a product's life cycle is complex and time-consuming. In order to be able to optimise environmental performance, we need to weight different impacts to a common number. In LCA terminology, this is called weighting. In order to make weighting possible, we need to express environmental impacts via indicators that can be compared to some reference or valued. These indicators are called impact category indicators and may be chosen early or late in a cause-effect chain, but existing weighting methods today either use emissions or transformed emissions and compare with emission goals or use monetary valuation of damages.

The Eco-indicator method as described by Goedekoop (1995) and Goedekoop et al. (1998) has resolved these problems. The LCA method has been expanded to include a weighting method. This has enabled one single score to be calculated for the total environmental impact based on the calculated effects as is introduced by Kortman et al. (1994). During the development of the weighting method for the Eco-indicator much attention was given to defining the environmental impact. The problem lies in determining the weighting factors. In this method, the so-called Distance-to-Target principle was chosen. This principle has been in use for some years in the Swiss Ecopoints weighting system, introduced by Ahbe (1990). The underlying premise is that there is a correlation between the seriousness of an effect and the distance between the current level and the target level. In order to assess the overall impacts of trade-offs, the relative importance of various environmental problems must be determined. A recently developed LCIA is the Eco-indicator 99 by Goedekoop (2000), the successor of the Eco-indicator 95 method. This approach considers the analysis of three related spheres, namely the technosphere, ecosphere and valuesphere, following the cultural theory and implemented by Hofstetter et al. (2000). The technosphere is the domain of technological processes and systems developed by human. The ecosphere is the domain of ecological processes and systems, and incorporates the technosphere. The valuesphere is the domain of human valuation and includes both subsystems. For the valuesphere (value choices), three perspectives were developed. According to the attitude of three human archetypes (individualists, egalitarians and hierarchists), the ranking and distribution of weighting factors between human health, ecosystem health and resources were determined. According to the selected valuation approach, a single indicator is obtained.

There can be little doubt that buildings are important contributors to environmental deterioration. Buildings contribute 15% to 45% of the total environmental burden for each of the eight major LCA inventory categories. In any design, trade-offs must be made among

solutions aimed to optimise building performance for various objectives. Environmental objectives are diverse, complex, interconnected, and frequently conflicted. Decision-making tools such as multiple attribute decision analysis can assist designers and their clients resolve conflicting project goals that normally are part of any project. Systematic analysis based on empirical data has provided the tools necessary for designers and other decision-makers to evaluate the trade-offs they must make between environmentally-friendly building features.

3. CASE STUDY

The purpose of the calculation is to establish priorities, or in other words - where can the designer best to achieve the greatest possible environmental profit? In the first instance it is possible to make fairly rough calculations and simplifications are permissible. In a life cycle perspective there is an optimum, where the incremental increase of impact from environmental performance and from equipment construction demands equals the incremental decrease of impacts from increasing efficiency – see Figure 1.

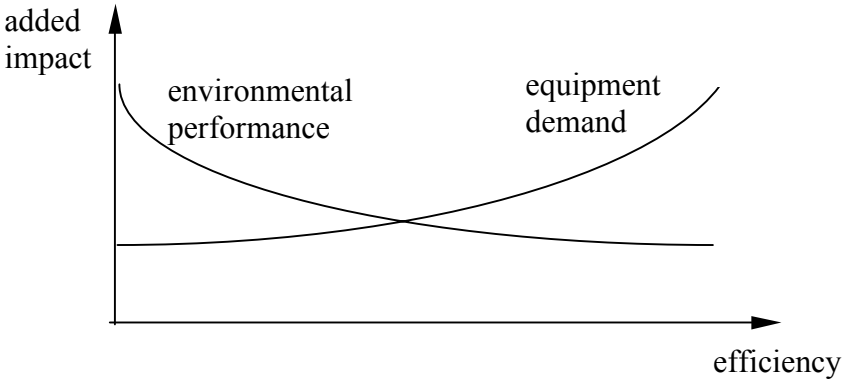

Figure 1 Optimisation of environmental performance of heating and air conditioning systems

The analysis was performed for one building floor for heating or air conditioning system. In continuation of article it is shown the comparison between three different heating systems. For all these three different heating systems we took the same building floor for case study. Hence this the required heating/cooling power (11,8 kW) is the same for all heating systems.

A simplified life cycle of heating or/and air-conditioning systems is given in Figure 2. Such a process tree provides a useful insight in further analysis.

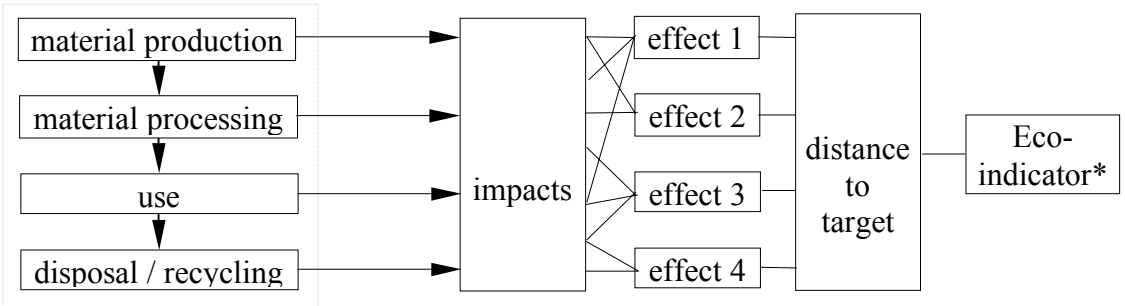

Figure 2 Example of simplified life cycle for heating and air conditioning system. The use phase determines the overall functional unit of a product.
*The result is given in milli Eco-indicator point (mPt)

3.1 Radiator heating

In the case of radiator heating system, two different systems are analysed. The main difference was the chosen material for piping system (steel/copper) and for radiators – heating panels (steel/aluminium).

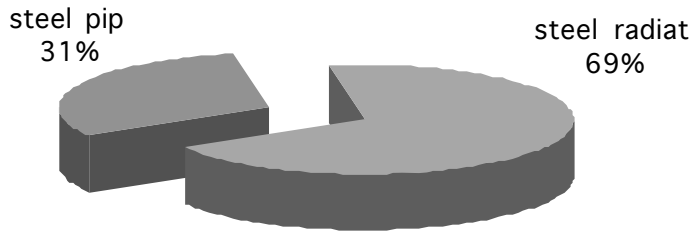

Figure 3 Eco-indicator value for steel radiator heating; pipe length 78,4 m, material for radiator 0,927 Pt, pipe 0,412 Pt, total 1,339 Pt

In Figure 3 is presented the result of analysis for steel radiator heating system with steel pipes, made by Eco-indicator method. The results reveal the great importance of radiator (greater mass of radiator than pipes) which presents the 70 % of overall impact. Total Eco-indicator is 1,339 Pt.

The results of similar analysis for heating system with aluminium radiators and copper pipes (as alternative) are shown in Figure 4. As it is seen in Figure 4, the copper pipes for aluminium radiator heating are dominant among the materials for environmental impact. Copper pipes represents 56 % of overall impact for the given example, despite smaller dimensions. Total Eco-indicator is 4,0 Pt, and is much more as for the steel system.

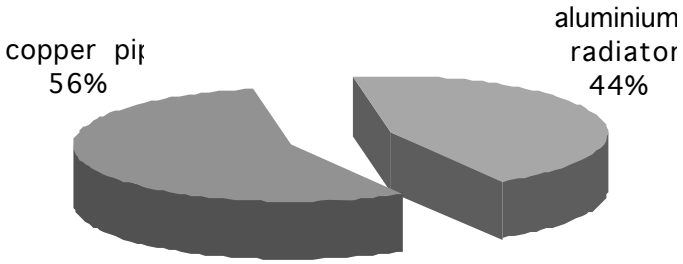

Figure 4 Eco-indicator value for aluminium radiator heating; pipe length 78,4 m, material for radiator 1,774 Pt, pipe 2,234 Pt, total 4,0 Pt

3.2 Floor heating

Eco-indicator value for polyethylene pipes, dimension 14×2, is 0,089 Pt and for polybutene pipes, dimension 16×2,2, is 0,111 Pt. Pipe length was 291 m and was the same for both systems. Difference was only in pipe material, while all other parameter were the same. While the heating demand is the same regardless the heating system, analysis results are comparable to other systems, since they are expressed in the form of Eco-indicator points. Smaller (better)

eco-value for floor heating system is also the consequence of the fact that the extra building construction was not considered.

3.3 Fan coil convector

For the analysis, the exposed floor fan coil convector unit was chosen with average parts (valves, fittings etc). The base unit is made of 1,0 mm thick galvanized steel plate. Cold panels are insulated. The fan section is composed of a cross-flow tangential fan and special air discharge sections that ensures a uniform distribution of the airflow. The three-speed motor is mounted on flexible supports. Cabinet is made in five separate pieces, a front panel in 1 mm thick galvanized steel and painted with a durable baked polyester powder coating. Pipe coil is a copper tube and lanced aluminium fin construction. The convectors were chosen in accordance with heating power. The convectors are substitute for radiators. For piping system, one could assume the same conditions as for the radiator heating system. Since the fan coil unit consists from various parts, we could determine the Eco-value for different part. In Figure 5 is shown the Eco-indicator value for different materials and in Figure 6 for different parts. From these figures the influence of different materials in different parts of unit is obvious.

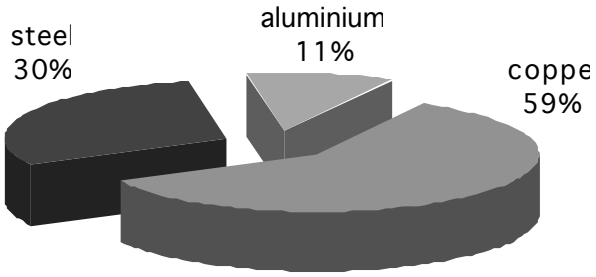

Figure 5 Eco-indicator value for fan coils (convector heating / cooling), by materials, total 3,126 Pt

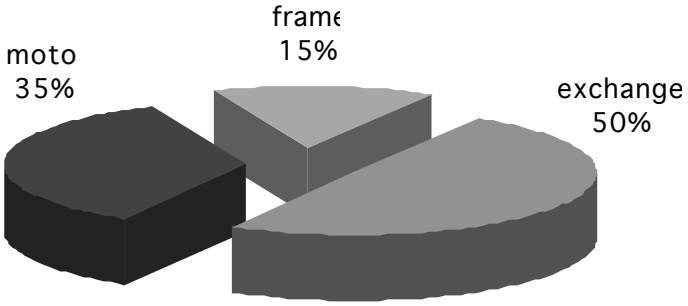

Figure 6 Eco-indicator value for fan coils (convector heating / cooling), by elements

In Figure 6 is presented the result of analysis for fan coil units. Heat exchanger is made of aluminium plates and copper pipes, which contributes the greater Eco-indicator (50 % of the whole unit). Total Eco-indicator is 3,126 Pt.

4. CONCLUSIONS

The Eco-indicator method has been used for the analysis and optimisation of heating and air conditioning systems. This method enables environmentally-aware design and is open working method with a platform on which both industry and science can integrate the environmental aspects into the design process. These design alternatives can be calculated in the same way with this method. The result permits the user to see how much environmental impact of these design alternatives will have. The designer can analyse the consequences of an idea quickly and effectively and establish clear selection criteria for an idea.

Prerequisites for a fair comparison of environmental characteristics of different heating and air conditioning systems are:
that the systems compared are equal and fulfil the functional requirements,
the limits of the systems are drawn up by the same principles,
technical characteristics and material data of the systems and equipment are reliable,
environmental profiles of energies and materials used in the comparison are comparable.

This research showed that three different concepts of heating systems with different construction materials varies the Eco-indicator value. We can see that for radiator heating system the Eco-indicator value is far superlative than for floor or fan coil convector heating system. Copper pipes and other copper parts contributes to the greatest environmental impact. Radiator heating Eco-indicator (1,339 Pt – steel pipes and 4,0 Pt – copper pipes) showed three times higher value for copper pipes than for the steel pipes. The lowest values are obtained for floor heating systems, but no extra building construction was considered.

Reasonable values are obtained for fan coil units (convector heating/cooling) with Eco-indicator value 3,126 Pt. Analysis show up, that heat exchanger (copper pipes) contributes the main part of the value. Nevertheless, the environmental aspect is only one of the evaluation criteria in addition to cost, aspects of use and standards.

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Leaching of harmful substances from recycled aggregates in laboratory and field site

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1. INTRODUCTION

Possible environmental impact from the recycling of demolition waste has received considerable attention in the last two decades. The Netherlands started to study this topic in the early 1980s followed by Germany. Tränkler et al. (1996) concluded that the research carried out on this field in the 1980s and at the beginning of 1990s demonstrated the need for further investigations with respect to environmental impact of demolition waste recycling.

The last 5-10 years further research have been reported with respect to laboratory leaching characteristic. Some important publications are Hohberg et al. (2000) and van der Sloot (1998). Compared to these studies, few investigations exist on leaching characteristics in full scale. The only field experiment study on leaching, to the author's best knowledge, was carried out by Schreuers et al. (2000).

RESIBA-Recycled Aggregates for Construction and Building an EcoBuild project, aimed to make recycled aggregates (RCA) a competing product for a range of applications. The goal is to bring Norway up to the same level as the rest of Europe in terms of the use of recycled building and construction materials, thus reduce the impact from the industry on the environment. This paper presents the results from the environmental part of the project. Leaching characteristics of RCA, mainly containing concrete and masonry, were studied in laboratory and under field conditions (demonstration project). The results from leaching tests in laboratory formed the basis of the demonstration project. In the full scale investigation the release of different chemical constituents from 3 years old RCA used as backfill in a utility trench was studied. The aim of the study was to investigate any environmentally harmful influence of the soil system caused by RCA in the trench and the correlation between the leaching in lab and field.

2. EXPERIMENTAL

2.1 Laboratory leaching

In Europe several laboratory test methods exist concerning leaching from recycled demolition waste (Engelsen et al., 2002). The standardized test method prepared by CEN/TC 154 (prEN-

1744-3) has been developed to determine the leaching from natural and recycled aggregates, thus using this method in the laboratory tests. The individual test samples shown in Table 1 were collected from the producer of recycled aggregates in Oslo (BA Gjenvinning AS).

Table 1 Investigated samples, particle size and the methodology used are shown.

Sample description*	Particle size (mm)	Date of sampling	Method**
0-10 CM1	0-10	June 1998	L+T
0-10 CM2	" "	" "	L+T
0-10 C	" "	" "	
10-20 CM1	10-20	" "	L+T
10-20 CM2	" "	" "	L+T
10-20 C	" "	" "	L
10-38 CM1	10-38	November 2001	L
10-38 CM2	" "	" "	L
LECA CM***	< 32	October 2001	L
LECA Ref	" "	" "	L

*C and M denote crushed concrete and masonry respectively. The figure after M indicates the sampling number. LECA CM was LECA (light expanded clay aggregates) lightweight masonry concrete block casted in laboratory with a mixture of 30 % of RCA (0-10 CM) by weight as replacement for natural aggregates. LECA Ref is a reference sample casted without RCA (natural aggregates only)

**L and T denote the determination of leaching characteristic and total content respectively.

2.2 Leaching under field conditions

The RCA in a utility trench (Figure 1) parallel to the freeway (E18, Skullerud, Oslo) was studied. The trench contained a surface water drain pipeline intended to collect the surface water from the road surface, and conduct it to a precipitation reservoir. The pipeline was enclosed by RCA (not in physical contact with the collected surface water), which replaced the natural aggregates.

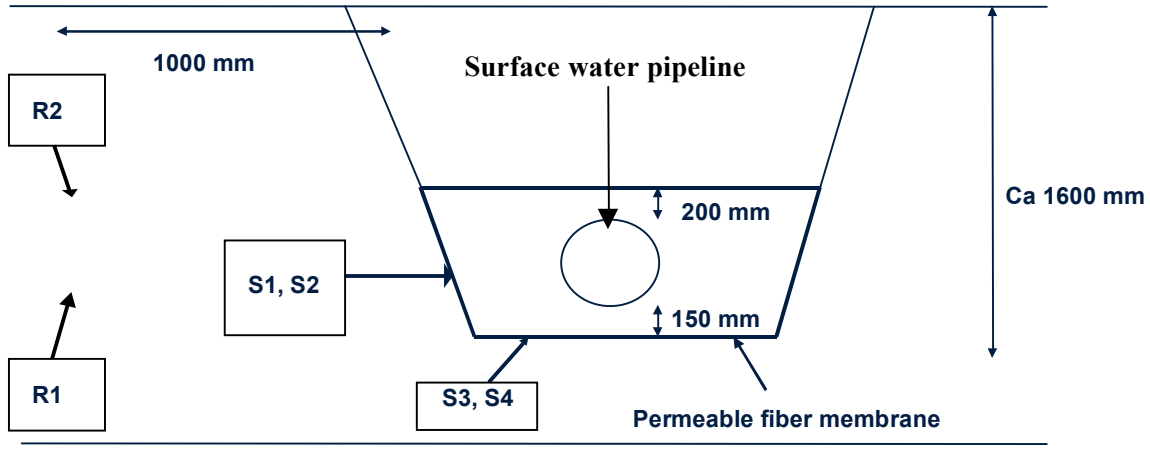

Figure 1 Cross section of the utility trench. The permeable fiber membrane encloses the RCA and the pipe.

A water permeable fiber membrane enclosed the RCA and the surface water pipe. Local soil (clay minerals) surrounded the enclosing membrane. The RCA backfill (10-20 mm of mainly

crushed concrete and masonry), have been exposed under these conditions for 3 years in the trench.

The location of the sampling is also shown in Figure 1. Soil and soil water situated close to the RCA, S1-S4, were sampled for chemical analysis. In addition reference samples (soil and soil water), R1 and R2, were sampled for comparison tests approximately one meter away from the trench. Sampling of soil water was carried out with lysimeters (ceramic tubes) attached to a vacuum pump.

2.3 Chemical constituents and analysis.
The following inorganic and organic constituents were determined in the samples: As (arsenic), Pb (lead), Cd (cadmium), Cr (chromium), Cu (copper), Hg (mercury), Ni (nickel), Zn (zinc), Ca (calcium), Cl (chloride), SO_4 (sulphate), PCB (polychlorinated biphenyls) and PAH (polycyclic aromatic hydrocarbons). In addition, determination of pH in eluates and the collected soil samples was carried out.

The chemical analyses were performed out with techniques and principles expressed in the literature. Atomic absorption spectrometry (GFAAS and FAAS) and inductively couplet plasma atomic emission spectrometry (ICP-AES) were used in the determination of As, Pb, Cd, Cr, Cu, Hg, Ni, Zn and Ca (Engelsen and Wibetoe 2000, Kos et.al. 1996). For the determination of PCB and PAH gas chromatography (GC) was used (Lazzari et.al. 1999, Boiselle et.al. 1987). Determinations of Cl and SO_4 were carried out according to the Norwegian standardized methods NS 3671 (1987) and NS 3090 (1970) respectively.

3. RESULTS AND DISCUSSION

3.1 Laboratory leaching
Amounts of Ca and Mg versus pH after 24 h leaching were determined as shown in Figure 2.

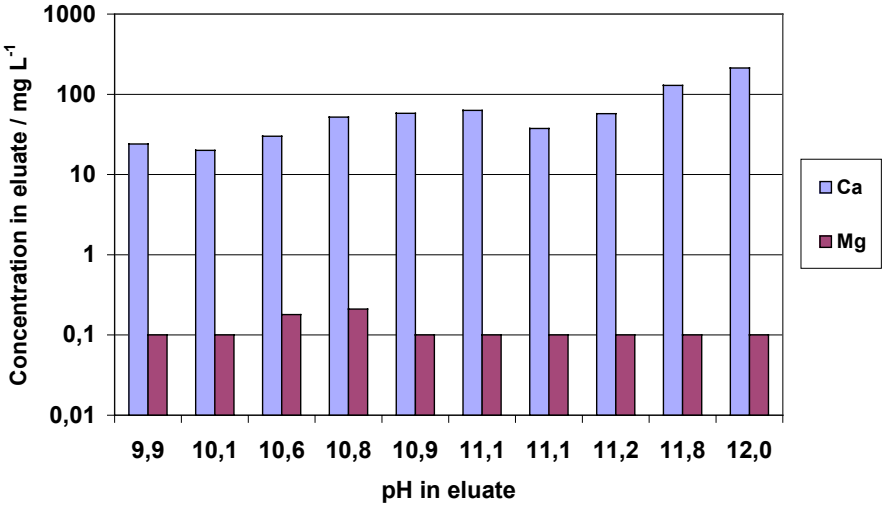

Figure 2 Element concentrations of Ca and Mg versus pH in eluates after 24 h leaching in 10 different experiments.

A significant increase in the leached amount of Ca with increasing pH in the eluate was found. Similar measurements for Mg showed no increased amount with increasing pH in the eluate. The achieved relationship between the leaching of Ca and Mg were also found under field conditions, and will be shown later.

The results achieved in laboratory were compared to different leaching criteria in Europe shown in Table 2. The released amounts of heavy metals from RCA did not exceed the threshold values in Germany, Austria and Switzerland regarding leaching.

The leaching threshold values in Germany and Austria are based on a German test method (DIN 38414 1984), and the Swiss values are based on a Swiss test method (Bericht zum Entwurf für eine Technische Verordnung über Abfalle 1988), thus indicating that reservation has to be taken when comparing these values. However, these methods have similarities such as; they are all batch tests, they have 24 h exposure time and the liquid to solid ratio (L/S) is the same. Due to these similarities a comparison will give a realistic indication of the achieved results in RESIBA.

In terms of organic constituents in recycled demolition waste, most of the European countries have threshold values related to the total content in the material. In this respect total organic carbon (TOC) is used as a common parameter. Organic substances such as PCB and PAH are not related to specific threshold values i.e. these substances are part of the TOC content.

Due to the lack of specific threshold value, the release of PAH measured in RESIBA (Table 2) was compared to Norwegian drinking water requirements (Norwegian Drinking Water Directive). The requirement for Norwegian drinking water is 0,1 µg/L regarding PAH. The achieved results did not exceed this value.

Table 2 Leaching results achieved in RESIBA compared to different European leaching criteria.

Parameter	Eluat concentration / μgL^{-1}			
	Germany[1]	Switzerland[2]	Austria[2]	RESIBA
As	50	10	50	< 1
Pb	100	100	100	< 10
Cd	5	10	5	< 0,5
Cu	200	200	200	< 5-46
Cr	100	50	100	< 5-43
Hg	2	5	1	< 0,05-0,16
Ni	100	200	100	< 5
Zn	400	500	1000	< 5
PCB	----	----	----	< 0,005
PAH	----	----	----	< 0,02[3]

[1] Deutscher Ausschuss für Stahlbeton-DAfStb 1998
[2] Karstensen et.al. 1999
[3]The sum of benzo(b)fluoranten, benzo(k)fluoranten, benzo(ghi)perylen and indeno(1,2,3-cd)pyren

3.2 Leaching under field conditions

Amounts of Ca and Mg in soil water sampled close to the RCA (S1-S3) and amounts in the reference sample (R1) are shown in Figure 3. Significant difference between S1-S3 and R1 was only found with respect to the amounts of Ca, thus measuring approximately the same

concentration of Mg in all samples. The measurements were repeated after one year out (autumn 2001) and similar results were achieved.

A thorough investigation of the soil-pH was carried out to complete the measurements of Ca and Mg. The results are shown in Figure 4. The pH was significantly higher in S1-S4 (soil located next to the RCA) compared to the references R1 and R2. This clearly proves the influence of RCA with respect to leaching of alkaline substances such as Ca species [$Ca(OH)_2$ and $CaCO_3$]. Considering the facts that Ca and Mg are natural constituents in soil, they appear in the same concentration order of magnitude and they are essential parameters in soil chemistry, the achieved results demonstrates the influence from RCA on the soil system in terms of the leaching of Ca species and increased soil-pH.

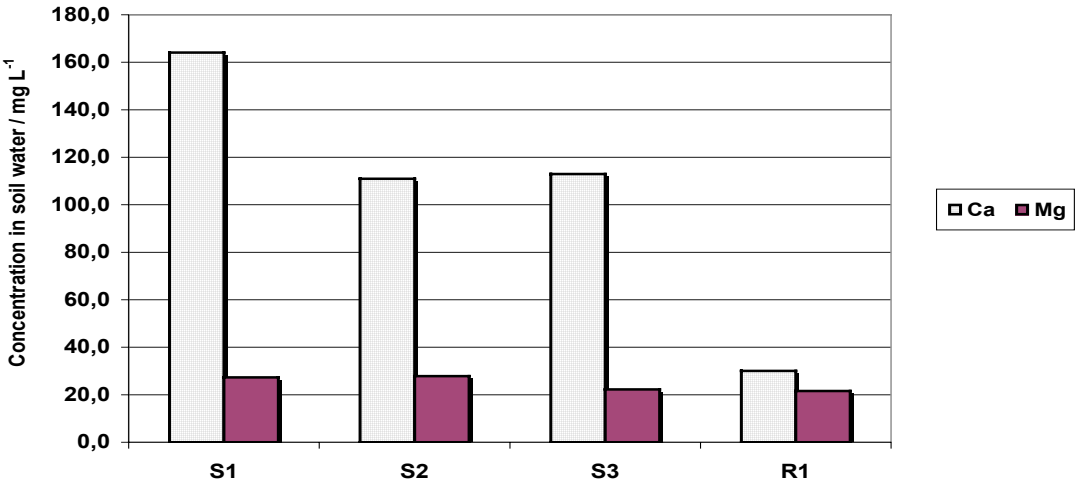

Figure 3 Comparison of sample S1-S3 related closed to RCA with reference sample R1.

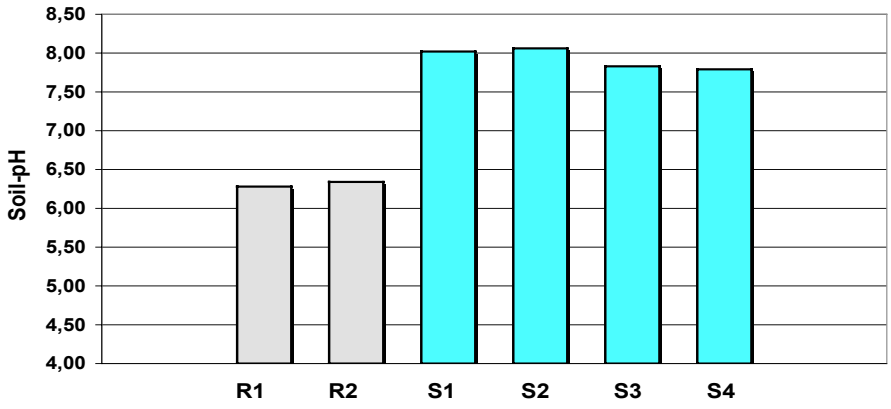

Figure 4 Comparison of soil-pH in S1-S4 and the references R1-R2.

Soil is able to adsorb heavy metals and organic components such as PCB and PAH due to the composition of the soil particle (Appelo and Postma 1993). In polluted soil these substances are often detected. Consequently soil in the utility trench was sampled for analysis in order to prove any possible accumulation. The results are given in Table 3 and were compared to the soil requirements in sensitive areas with respect to human being exposure (Norwegian Pollution Control authority. 1999). With few exceptions no significant difference was found between S1-S4 and R1-R2. Compared to the soil requirements, only As was found in significantly higher amount. Since no significant difference between S1-S4 and R1-R2 was found for As, these concentrations could be natural background level or emitted from other sources than RCA.

Table 3 Total content of different substances in the soil samples.

Parameter	Concentration / mg kg^{-1}						
	S1	S2	S3	S4	R1	R2	Regulated value*
As	3,6	3,2	2,7	2,8	3,1	2,5	2
Pb	15	20	12	13	21	14	60
Cd	0,1	0,1	0,1	0,05	0,1	< 0,02	3
Cu	13	15	10	13	22	15	100
Cr	23	27	23	24	28	28	25
Hg	0,019	0,020	0,014	0,017	0,039	0,015	1
Ni	21	21	18	20	22	26	50
Zn	72	68	55	20	85	66	100
PCB	< 0,01	0,01	< 0,01	< 0,01	< 0,01	< 0,01	0,01
PAH	2,5	0,14	0,04	0,2	0,24	< 0,01	2

*Threshold values for soil in very sensitive areas i.e. areas where people are put through exposure in several different ways. Norwegian Pollution Control Authority issues these values.

4. CONCLUSION

Leaching results achieved in RESIBA comply with the criteria in Germany, Switzerland and Austria using pr-EN 1744-3 as test method with respect to leaching of heavy metals. The eluat concentration of PAH did not exceed the threshold value Norwegian drinking water.

No influence from RCA with respect to heavy metals, PCB and PAH on soil was found in the field investigation. The only influence on soil from RCA was the release of Ca and consequently an increase in the soil-pH was found, which is not considered as a negative environmental impact.

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Concept for a DC low voltage house

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1. INTRODUCTION

As a result of increasing environmental concern, the impact of electricity generation on the environment is being minimised and efforts are being made to generate electricity from renewable sources. Although widespread use of renewable energy sources in electricity distribution networks is still far away, high penetration levels may be reached in the near future at a local level in new suburban areas, where much attention is paid to renewable energy, One of the sources to be used is the sun. Due to the intermittent nature of solar energy supply, stand-alone PV systems require electricity storage. In locations where a public electricity grid is available, 'storage' by grid connection is usually considered to be more convenient than privately-owned electricity storage. Grid connection requires a conversion from direct current (DC) to alternating current (AC). This conversion also enables the use of standard AC supplied household equipment.

Many household appliances, however, work internally on DC. This implies the need for a transformer inside the appliance, in order to convert the AC current of 230 V to (low voltage) DC current. Using PV with an AC grid thus involves two energy conversions, with inherent energy losses. It is reasonable, therefore, to assume that introducing a DC (low-voltage) grid can mitigate these losses.

The feasibility of this idea has been studied by the ECN (Energy Centre The Netherlands) [1], by comparing a stand-alone PV-powered AC house to a stand alone PV-powered house provided solely with DC electricity. A conventional lay-out was used for both situations, with up to 40 meters of cable length. Their conclusion was that introducing DC would not lead to a significant reduction of energy losses. This result is, however, strongly influenced by the original assumption of a conventional indoor distribution layout.

2. OBJECTIVES AND SCOPE

The aim of this research is to investigate to what extent the energy losses in a PV-powered house can be mitigated by introducing a DC low voltage distribution system. The present study focuses mainly on two issues, which have been given relatively little attention in previous research:

- What if both AC and DC are used, so that higher power demands are met with AC, and lower power demands with DC electricity?
- Is it possible to reduce distribution losses by adapting the design of a standard house, so that the distances in the indoor distribution lay-out are limited? At present the power

losses in the DC low-voltage distribution system are high due to large distances in standard indoor grid lay-outs.

Differences in losses between DC/DC and AC/DC converters were also looked at in the present study, but to a lesser extent. Previous research by ECN did not take into account the losses at the supply side of household appliances.

The conceptual design of the DC system starts from a reference house, currently being planned for the 'Groene Kreek', a district in the city of Zoetermeer, The Netherlands. The reference house is being redesigned into a concept house, which is optimised to incorporate a DC distribution system, photovoltaic electricity generation (PV) and storage. No loss of comfort for the inhabitants is a sine qua non condition.

3. RESEARCH OUTLINE

In order to meet the above-mentioned objectives, the following items are studied. First of all, different sorts of solar panels are investigated and a choice of solar panel type is made. The amount of generated electricity is calculated based on the availability of sunlight in the western part of The Netherlands and on an assumed efficiency of 10% for the chosen panel. A study is also done on the suitability of household appliances to work on DC low-voltage current, in order to estimate the electricity demand (DC load) and the number of solar panels necessary to feed the selected DC appliances. Combining these data for supply (PV panels) and demand (DC loads) enables a rough estimate of the storage capacity, and a tentative choice of an electricity storage system. The storage system choice also considers the possibility to spatially integrate the electricity storage into the house.
The distribution system is looked at in more detail. This study focuses on whether clustered DC appliances and a different lay-out of the house can lead to smaller distances in the indoor distribution grid, and hence to smaller electricity transport losses. A design is made for a distribution system in a concept DC- house, and the transport losses are calculated for the optimised lay-out. Finally the transport and conversion losses in the DC house are compared to the losses in a standard AC house, and conclusions about the feasibility of the DC distribution system are drawn.

4. RESULTS AND DISCUSSION

4.1 Solar-energy conversion.

Solar-energy can be converted into electrical energy and into heat. Photovoltaic cells (PV) are used for the conversion into electricity. For the concept house, poly-crystalline silicon cells with an efficiency of 10 % are assumed. This technique is the best developed at the moment, and is affordable for consumer use. The panels are placed on the flat roof of the building, facing south at an angle of 45 degrees from the horizontal plane. It is estimated that 24 square meters of solar panel can meet demand and provide a small overcapacity, to make sure that electricity demand can be met also during bad summers.

For the electricity output, data [2] are used concerning the average daily sun radiation over a year, based on yearly averages, yearly and daily averages. With these numbers the electricity output for the 24 square meters of panels with an efficiency of 10 % is estimated. The results are shown in the next section together with the estimated demand. (see Figure 3)

4.2 Electricity demand in the DC low voltage house.

To estimate the DC and AC loads in the concept house, first the total electricity demand is assessed [3]. Average annual electricity consumption in the 'Groene Kreek' is estimated to be slightly higher than the average of 3500 kWh per year in the Netherlands. Based on the income levels of future inhabitants, average yearly consumption per household in the 'Groene Kreek' is estimated to be ca. 4000 kWh.

This is the total output for both AC and DC electric loads, regardless of which appliances can be supplied with low-voltage DC, and of how much they consume. The suitability for DC supply strongly depends on how electricity is converted. In principle, every appliance can be made suitable, but some groups of appliances are easier to adapt to DC electricity supply, or already function on an internal DC supply. The suitability for low voltages depends on the power demand of the appliance: only low power demands are suitable (< 150 W) to low-voltage, or else the losses in the distribution system will be too high (see section 3.3)

Table 1: overview of appliance suitability for DC low-voltage supply.

Kind of energy conversion	Examples	Suitability for DC supply	Suitability for low-voltage
Electric → heat	boiler, coffee maker	++	+/-
Electric → rotational or mechanical	Washing machine, fan .	+/-	+/-
Electric → sound and vision	TV, radio, CD player.	++	+
Electric → light	Fluorescent lamp, light bulb	+/-	+

The suitability of DC low-voltage supply is investigated for four different groups: [4] TV and video appliances; lighting; small kitchen appliances which do not generate heat; and appliances using batteries (e.g. electrical toothbrush, cooling appliances). The total electricity demand is found to be 2400 kWh for DC, and 1500 kWh for AC. This DC demand is used for the calculation of the required number of solar panels.

Whether DC electricity supply can actually lead to a reduction in energy conversion losses depends on the efficiency of DC/DC and AC/ DC conversion. If the chosen voltage level (24V) matches the voltage level needed by the DC appliance, no voltage conversion is needed. However, several household appliances work on different voltage levels, which implies a need for voltage conversion also with DC supply. A possible reduction of energy losses thus depends on the losses in both AC/ DC and DC/ DC converters. In this study, tentative measurements have been made of the AC/ DC losses in household appliances. Significant electricity conversion losses were detected but the evidence is not yet conclusive. For the losses in DC/ DC converters, information was obtained and compared from various manufacturers. The various data indicated an average DC/DC converter loss of ca.10 percent.

4.3 The DC distribution system

In the concept house proposed in this research, the DC electricity is transported by means of a low-voltage distribution system. This has to be done in a safe way, with as little losses as possible. The voltage chosen for the DC grid is 24 V, due to compatibility with most PV panels and storage systems. To transport the same power load as normal at this voltage, a higher current is needed. As a result, power losses are higher because of a quadratic increase of losses with current.

$$P_{loss} = I^2 * R \quad (4.3.1)$$

where P_{loss} = power losses; I = current; R = resistance

These losses can be reduced by lowering the resistance, which can be reduced by shortening the length of the distribution cables or enlarging the diameter.

$$R = \rho * l / A \quad (4.3.2)$$

where l = length of cables; ρ = specific resistance; A = diameter of cables

In this study, we investigate the possibility of reducing transport losses by shortening the length of electric distribution cables. The possibility of enlarging the diameter, perhaps even by a totally new electricity distribution concept, is not considered here. In this study, the spatial layout of the entire house is scrutinized and adapted so as to enable shorter lengths of indoor electricity distribution cables.

4.1.1 Building lay-out. The spatial layout of the concept house is adapted in this study, in order to reduce cable length and enable the use of DC, without loss of inhabitant comfort. Because the DC electricity source (solar panels) is on the roof, the rooms in the house are arranged so that the living room and kitchen (where most DC electricity is used) are placed closest to the source. This implies placing the living areas on the upper floor and the bedrooms on the ground floor, which is the opposite of a typical Dutch house layout. The intake point of cables from the solar panels is placed in the centre of the house.

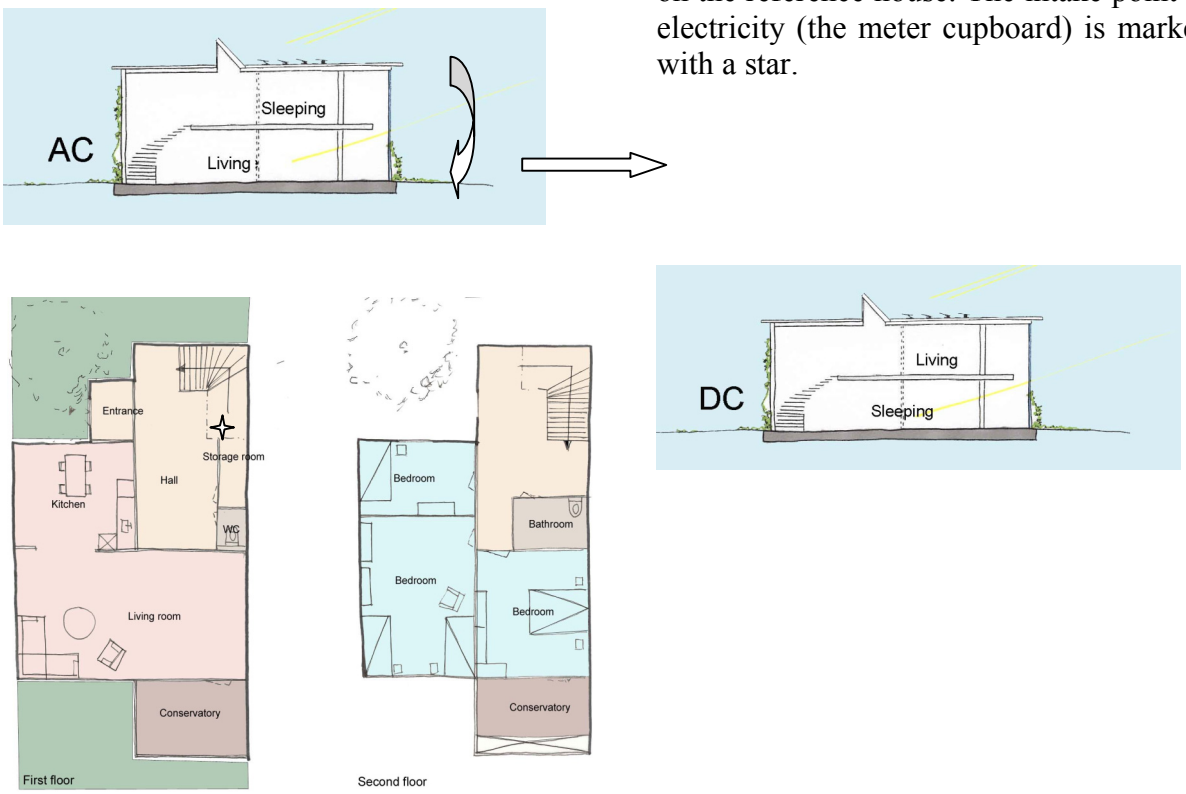

Figure 1: Lay-out of the AC house, based on the reference house. The intake point of electricity (the meter cupboard) is marked with a star.

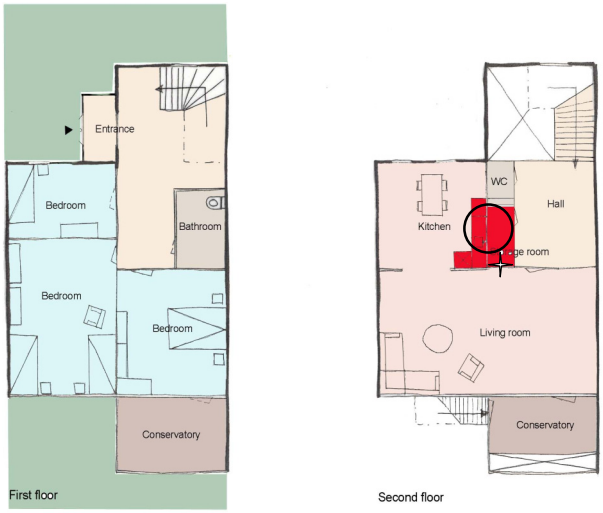

Figure 2: Lay-out of the DC concept house. The intake point of electricity is on the second floor, in the centre of the house. (marked with a star). Cirkeled is the zone where AC appliances are concentrated.

With this arrangement, and due to the placement of the electricity intake point in the middle of the house, cable length is reduced to a maximum of 12 meters, from the normal 40 meters in a standard AC house. Furthermore, all the AC appliances (mostly in kitchen and bathroom) are clustered in one single zone, so that an extensive AC grid is not necessary.
Furthermore, electrical installation plans are made for the DC concept house and for the reference AC house, to enable calculation and comparison of electricity losses in the distribution system.

4.4 Electricity storage

Since a stand-alone PV house is assumed, there is need for electricity storage. Storage systems suitable for usage in houses are flywheels, batteries and, if a good storage solution can be found, possibly hydrogen in the future. At this moment, lead-acid batteries seem to be the best option. In the future, lithium-ion batteries will form a cheaper and safer alternative. The required electricity storage system capacity is estimated in this study by comparing electricity demand from DC appliances (see section 4.2) and supply from the PV panels.

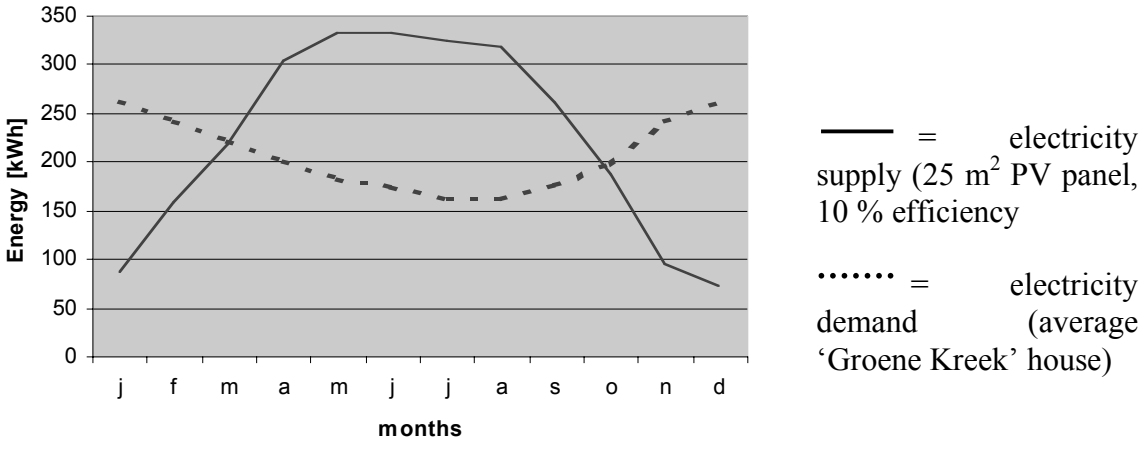

Figure 3: estimated yearly electricity demand and supply in the concept house [4]

A global estimate for a year-round storage system size can be made from figure 2. The storage system needs to cover ca. 600 kWh. This implies several cubic meters battery storage per house. Because of these large dimensions, another option is to cover only night time demand during the summer months (March until October), and use alternative power

generating devices during the remainder months. This topic needs further research, but is not addressed in the present study.

4.5 Estimated overall system losses.

The relative losses in the whole system, from generation until end-use, are estimated for the DC low-voltage concept house and for the AC reference house. [4]

Table 2: estimated relative losses in the whole distribution system

	DC/ AC converter, PV → distribution	distribution system	AC/ DC converters in household appliances	DC/ DC converters in household appliances
AC house	8 %	0.5 %	Not yet available	0 %
DC house	0 %	4 %	0 %	10%

5. CONCLUSIONS

In this study, a mainstream reference house design is optimised in order to accommodate DC electric power distribution and generation with photovoltaic. An investigation into electricity demand by an average household, PV supply, DC distribution and storage clarified the following:

- The introduction of DC-based distribution has a potential to reduce conversion losses, by eliminating the need for conversion between PV and distribution (DC/ AC), and within appliances (AC/ DC).
- An essential condition for the realization of this potential is building design optimisation; in this study an improved house lay-out led to a significant reduction in electricity distribution losses.
- Another essential condition (not verified in this study) is that the relative losses in AC/ DC converters in household appliances should prove to be more than ca. 6 %. In this case, the total power losses in the AC house would exceed the total power losses in the DC concept house, so that introduction of DC based distribution would mean a reduction of the total losses of electricity conversion and transport.

6. RECCOMMENDATIONS FOR FURTHER RESEARCH

Further research is needed on the following topics:

- Losses in AC/ DC inverters in household appliances and in DC/ DC inverters
- Possibilities for new distribution networks, with larger cross sections and improved comfort (accessibility, flexibility, safety) for the inhabitants.

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Ecological Modernisation vs. Ecocentrism? On Controversial Views regarding Strategies for Attaining Ecological Sustainability

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INTRODUCTION

During the last few decades, there've been a lot said and written on the topic of ecological sustainability and what to do in order to attain an ecologically more sound society. The Swedish philosopher Stig Wandén (1997) has formulated two seemingly contradictory statements which serve to represent very different views on, not least, the role of modern science and technology in the creation of an ecologically sustainable civilisation:

- We can keep and build on the modern industrial society, but we ought to change its rules so that it will function better and more efficiently. Especially, it's about creating new and environmentally proper technology and more rational economic rules so that the continuos economic growth doesn't damage the environment.
- We have to thoroughly reconsider the industrial society and should therefore directly sway the actors of the social system, that is ourselves. Our life style, our attitudes and behaviour must adapt to Nature's demands. Economic growth is precisely what damages the environment. (Wandén 1997, p 71. My translation)

The first statement represents what has become known as 'ecological modernisation', while the second one might be referred to as 'environmentalism'. Advocates of ecological modernisation hold that an ongoing strong development of technology and science can make the utilisation of Nature's limited resources more efficient, and this is thought not to entail curtailing industrial growth or changing the relationship with Nature (Dovlén 2001). Environmentalists, on the other hand, are giving much more importance to behavioural changes amongst the citizens of our society for the bringing about of ecological sustainability.

> the deep green ecologists, and arguably environmentalists more generally, severely underestimate the social and political obstacles to overcoming ecological crises and more satisfactory relations between people and nature. The deep greens in particular place enormous faith in changing personal consciousness. (Dickens 1992:3. Cited in Klintman 2000, p 72)

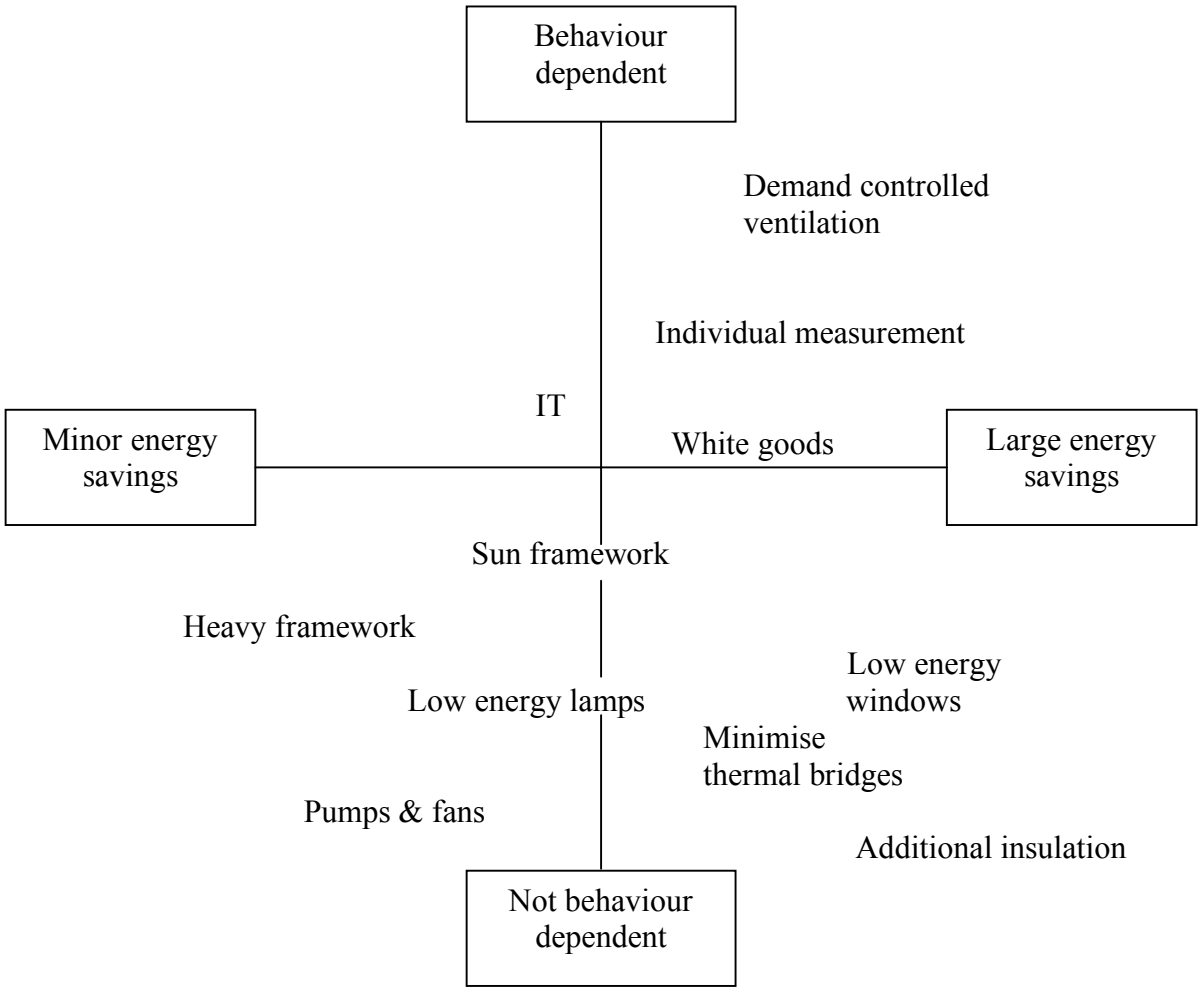
Thus it's obvious that one major difference between ecological modernisation and environmentalism lies in the fact that the former emphasise *technological and infrastructural changes*, while the latter puts forward *changes within people* as the primary recipe for our civilisation becoming ecologically sustainable. This paper focus these two approaches regarding the attainment of ecological sustainability and, more exactly, the tension between

them. The aim of the paper is to shed light on this very contradiction and, particularly, what consequences might appear if you try to practically realise both approaches in the same planning- or building project. In what way can these two approaches complement each other and, conversely, in what way are they mutually exclusive? The newly built area of Western Harbour in the Swedish town Malmö will serve as an empirical illustration of this mainly theoretically oriented paper.

ENERGY SAVINGS AND BEHAVIOUR DEPENDENCE

The Western Harbour in Malmö has been built because of the last year's European Housing Expo Bo01, City of Tomorrow. During the construction of these new houses and dwellings, a rather ambitiously formulated quality programme has served as a guideline for the whole project. Different kinds of standards and limits for the buildings are stated in this quality programme. Without going into detail about these standards and limits, I'd here like to mention one case in point: a limit of 105 kWh/m² gross room area annually has been set for the average energy use in the dwellings. In addition, this should be achieved with no loss of comfort for the residents. (*Quality Programme Bo01* 1999) To me, this could be interpreted as follows: the achievement of the limit regarding energy use should not be dependent on the actions of the residents. If it was, I think it would be difficult avoiding this dependence to entail *some* negative impact on the comfort of the residents.

There are a number of measures for energy savings in buildings. These different types of measures are to a varying degree dependent on the behaviour of the residents; some are to a great extent behaviour dependent, while other measures are not behaviour dependent at all. Consider the diagram below (from Nilsson 2001, p 95), illustrating different measures' level of behaviour dependence and their energy efficiency.



It is obvious that most of the measures in the precedent diagram are not very behaviour dependent. After all, many of these measures are applied to the building during the construction process and do not themselves affect the residents in any significant way. The most behaviour dependent measure is demand controlled ventilation and this measure is thought to stand for relatively large energy savings, too. (Many of the new dwellings of the Western Harbour have been equipped with such new technology, of which demand controlled ventilation may serve as a good example.) However, we've seen that the achievement of the limit regarding average energy use is supposed, according to the quality programme of Bo01, to entail no loss of comfort for the residents. How is this to be done, when one of the most important measures for energy savings is to such a great extent behaviour dependent? Now, it's necessary to make an important distinction between behaviour and *action*. This is a quotation from the English geographer Andrew Sayer:

> By "behavior" we mean nothing more than a purely physical movement or change, such as falling asleep, breathing, that is, doing things which lack "intrinsic meaning structure." In contrast, doings which we call "actions" are not wholly reducible to physical behavior even though they may be coupled with it. Actions are constituted by *intersubjective meanings*: putting a cross on a ballot paper, conducting a seminar, getting married, arguing, doing arithmetic, going on a demonstration are all examples of doings whose nature *depends* on the existence of certain intersubjective meanings (Sayer, 1979:20-1. Cited in Klintman 2000, p 68).

As many readers probably know, demand controlled ventilation is an energy saving measure which vital part consists of sensors reacting on the presence and absence of the residents. Thus, the eventual energy saving effect is a result of the *technology* in action – not of the residents' actions. In the case of demand control ventilation, behaviour dependence refers to the time being spent by the residents in the dwelling. It should be clear from the quotation above, that this behaviour dependence has nothing whatsoever to do with meaningful *actions* on the part of the residents. This, in turn, enables us to infer that applications of such technology do not imply any *changes within people*, due to the fact that the residents may well be totally unaware of the operation of this energy saving measure. Obviously, then, these behaviour dependent measures make an excellent example of ecological modernisation in the Western Harbour.

During the winter of 2000/2001 I made a couple of interviews with representatives of most of the 17 building companies involved in the creation of the Western Harbour. These interviews have been made as an initial part of an evaluation of the Western Harbour and, particularly, of the quality programme of Bo01. I'd like to cite one of my interviewees, whom I think personify ecological modernisation quite well.

> I think that much of what is called 'ecology' within this Bo01-project – like the surface water channels, for instance – might well be pedagogical and…making the circulation of the system obvious for people, so to speak. But, personally, I have a different point of view: The ecology must be something much deeper; you don't have to *see* it. Today, ecology is more about *technology*. It's not about roofs with grass growing upon them; there's nothing ecological with grass-roofs, actually. I mean, we have an energy supply problem and a waste disposal problem; it's here the ecology comes in and here you have to make use of technical solutions for those problems. Ecology is really about…moving

> from ‘low tech’ to ‘high tech’, you know. Grass-roofs is ‘low tech’, you know, but that has nothing to do with ecology. It may look ecological but it’s not *that* which constitutes the ecology in the area, but of course these infrastructural systems which you don’t *see* very much of. (Interview, 23/11 2000)

THE ECOLOGICAL RELEVANCE OF THE GREEN STRUCTURE

In the quotation above, the interviewee is a few times referring to the statements in the quality programme about the green structure in the Western Harbour, notably the prescription which states that 50% of the building sites’ area shall be covered with herbs or other plants. This prescription has led many building companies to lay out green roofs on their buildings, in order to put up with this 50%-limit. The open surface water channels in the area are also a manifestation of these high ambitions of Bo01 regarding the green structure of the Western Harbour. As been indicated above, the ecological relevance of these prescriptions about the green structure might, from an ecological modernisation point of view, seem questionable. Furthermore, it is a point of view which has been shared by many of the building company representatives that I’ve been interviewing. There have been a few exceptions, though. One interviewee said this about the open surface water channels in the area:

> Actually, I think it’s really pleasant with this pouring water. I believe that it, in one way or another, gives some kind of positive signals. And, you know, in a distant past we’ve all been originating from the sea. I really think that, when there’s water murmuring and the like…you feel in a way very positive and relaxed, don’t you? When you’re walking in the forest and there’s the murmuring from a brook or so…I think it’s really nice. (Interview, 20/12 2000)

Similar benevolent opinions about both the ambitiously planned green structure and the open surface water channels are displayed in a few of the interviews I’ve made. Now, what has this to do with ecological sustainability? There’s a hint of an answer in a section of the quality programme, entitled “Putting people first”:

> Man is a cultural being. At the same time he is biologically constructed for life in the natural environment. Human well-being depends on an environment which interacts with both these aspects. To achieve this, a district needs values which cannot be measured in the traditional manner: visual and acoustic impressions, the experience of greenery and water, street spaces with “human” proportions, and the subconscious understanding, interpretation and experience of one’s surroundings in a way which interacts with our biological origins, even in the distinctively man-made environment of the city. If these opportunities are provided and if these properties within ourselves are stimulated, a number of positive effects ensue. We feel happier, stress effects are reduced, our biological clock “keeps good time” and we are better able to get our bearings. By the same token, participation and the assumption of responsibility are made easier and we experience a sense of security and belonging. This is fundamental to the creation of urban environments which are sustainable – not just technically but in human terms as well. (*Quality Programme Bo01* 1999, p 15)

In addition to the palpable similarities between this section of the quality programme and the precedent quotation from one of the interviewees, we here get something of an explanation of how ‘the experience of greenery and water’ can be relevant for attaining ecological

sustainability. Participation and the assumption of responsibility are thought to be made easier by way of a somewhat subconscious sense of belonging. This participation and responsibility might be crucial for residents' adoption of a more environmentally proper life style, and the mentioned sense of belonging would thus refer to the relations between people and nature. A sense of belonging to the whole ecosystem (that is Nature) might in this way ensue. Now, this reasoning may seem pretty much divorced from reality. Anyway, this assumed healthy potential of the green structure and the water is thought to, albeit subconsciously, entail *changes within people*. As mentioned in the introduction, such a change, as well as the emergence of more 'belonging' relations between people and nature, are primary strains in environmentalism. Many environmentalists, and notably the so called deep green ecologists, put forward the importance of an *ecocentric* view of the world (Des Jardins 2001:10). This ecocentric view is to be contrasted with the more traditional anthropocentric outlook represented by ecological modernisation. It is interesting that, in the quality programme of Bo01, there's this element of ecocentrism within a document which otherwise could be described as something of a textbook example of ecological modernisation.

CONCLUDING DISCUSSION: COMPLETION OR CONTRADICTION?

Some readers may think that my analysis above is somewhat far-fetched, especially my comparison between the statements in the quality programme and the so called ecocentric outlook typically present among deep ecologists. Indeed, I've even over-simplified some things; there are, for instance, energy saving measures like individual measurement and IT – measures which entirely depend on meaningful and rational *actions*, on the part of the residents, for their functioning as energy savers. However, my aim with these examples from Bo01 and the Western Harbour has been merely to supply the readers with some empirical illustrations making my main argument in this paper more tangible. Let us now return to the stated question at the end of the introduction of this paper. In what way can these two approaches complement each other and, conversely, in what way are they mutually exclusive?

To begin with, one contradiction is apparent between the two approaches mentioned at the beginning of this paper: In the first mentioned approach technological development is believed to make the necessarily continuos economic growth better adapted to the environment, while in the second approach economic growth itself constitutes the main cause to the environmental problems. Here a contradiction is evident; there's no way making these mutually exclusive beliefs merge or adapt to each other. A *logical* contradiction is here to hand. But this truth is on a very general and, if you like, ideological level. Let's instead take a look at the contradiction(?) between the focus on *technological and infrastructural change* and the focus on *changes within people*, that is between the ecological modernisation approach and the environmentalist approach.

When I've been presenting my research in front of my sociologist colleagues, I've been confronted with this objection: If a new district is planned and built in such a way that the infrastructure and technology sort of 'takes care' of the ecology, why then bother trying to make the residents change their life style? This objection has seemed to me as a quite reasonable question. We have seen that demand controlled ventilation, for instance, works without any conscious intervention on the part of the residents. The energy savings that might result from the activity of demand controlled ventilation can be made *without any change in life style whatsoever*. In fact, demand controlled ventilation makes it easier for the resident to maintain living an excessive way of life and yet making energy savings, thanks to the demand controlled ventilation! Conversely, in the case of individual measurement, no energy savings can appear without any active involvement from the resident(s). The information which

constitute the measure of individual measurement is likely to have some impact on the resident's awareness regarding his/her own energy use. Thus, individual measurement may entail minor *changes within people*. Accordingly, individual measurement can be regarded as a behavioural changing measure, and thus as an instance of a slightly environmentalist approach to the attainment of ecological sustainability. Even though these two measures might be contradictory in a strictly *logical* sense, that is concerning their respective way of functioning or (if you like) their 'idea', there's no *actual* contradiction between them. The 'informative' and behavioural changing measure and the wholly technological measure really complement each other! The workings of one of these energy saving measures doesn't affect the workings of the other measure.

The same holds for the assumed impact of the greenery and water on the consciousness of the residents: This 'deep green ecologist' approach is not at all negatively affected by the fact that newly developed technological solutions have been applied in the district. So a final solution might be stated like this: The contradiction, to which the title of this paper hints, simply is not to hand! You could very well share an ecocentric outlook and yet make use of the modern, technological installations frequently applied in the Western Harbour of Malmö. This may seem self-evident to many readers, but personally I have to admit that I've been sort of enlightened during the writing of this paper. Perhaps one should let philosophy be just philosophy, and not try to analyse the concrete reality in the light of such abstract lines of thought…

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Re-use versus Demolition
A case study in the Netherlands

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1. INTRODUCTION

The Netherlands produces about 19 million tons of construction and demolition waste a year [Hendriks 2002]. No explanation is needed for saying that this is an enormous amount for a small country like The Netherlands. The Dutch Government passed a law on the first of April 1997 which states: "dumping of reusable building waste is prohibited" (short version).

To deal with the implications of the legislation we consider three possible solutions. Firstly, all new buildings can be built and assembled with renewable materials. Secondly, existing buildings can be upgraded if possible, and finally, if upgrading is not an option then buildings should be deconstructed into elements and components when possible (CIB TG30 Deconstruction).

According to Eekhout [1997] the top down hierarchy in building is: Building → Buildingpart → Components → Elements → Half-Products → Materials → Raw Materials. Every step higher in the hierarchy means that there has been an increasing value of: labour, energy, material and use of equipment. So product re-use should have the advantage over material re-use because of the fact that less value is lost.

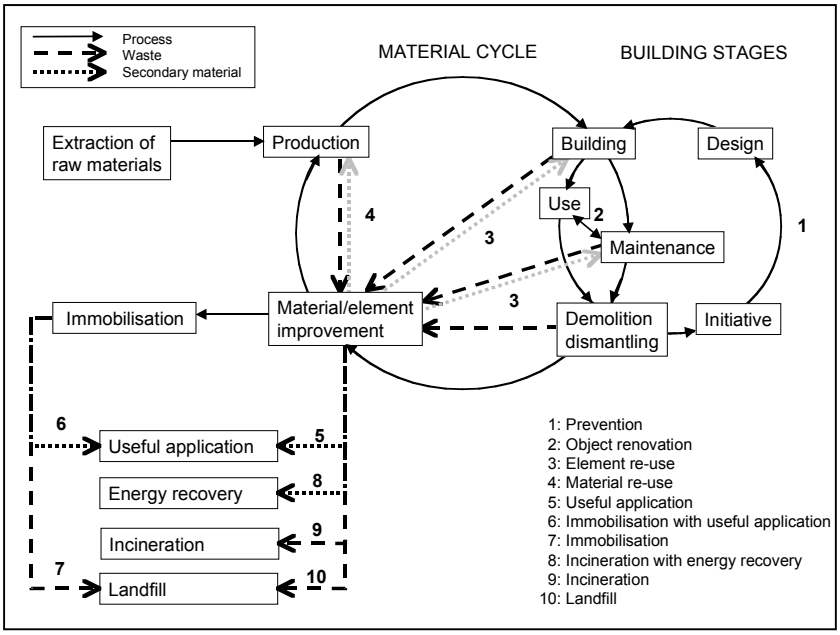

Figure 1: Integral Chain Management; coupling of the building stages and material cycle [Dorsthorst 2000]

The question arises in what way, and in which order, a building should be dismantled which is never meant to be dismantled? Dismantling a building into elements and components is a way to keep the building materials in their own cycle for as long as possible (integral chain management, Figure 1). The main advantage of this approach is that buildings will not be downgraded to secondary raw materials or building waste but into reusable elements and components.

This paper describes a case-study of the deconstruction and rebuilding of an old warehouse made of bricks. This building was never meant to be deconstructed.

2. DECISION SUPPORT MODEL FOR THE RE-USE OF BUILDING ELEMENTS

A decision support model has been developed for the re-use of old building elements or components. The structure of this model is a logical one (Figure 2). After establishing the building, location, building method, etc., the first question arises: is there a deconstruction technique available to deconstruct the element or component and if not can one be invented? If an element or component can't be deconstructed the building will be selectively demolished.

The next question is: can the element or component, even after upgrading, meet building regulations and material requirements? If not, the building should be selectively demolished. Finally when both steps mentioned earlier are possible the whole process will be calculated on economical and environmental costs. The best possible outcome is that the whole process will be profitable in both the economical and the environmental aspect. If it fails on the economical level a financial instrument, like taxes or subsidies, can change this. But if it fails on the environmental level it will be more difficult to succeed, because then dismantling a building into elements or components increases the environmental impact.

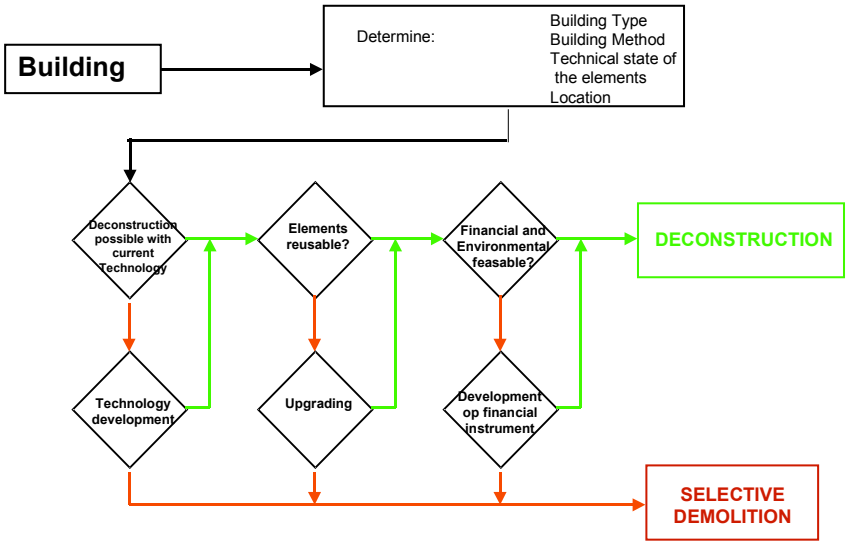

Figure 2: Decision Support Model [Kowalczyk 2000]

3. DECONSTRUCTION AND REBUILDING OF AN OLD WAREHOUSE

The Dutch Railways made a warehouse, in Middelburg, obsolete a few years ago. The intention was to demolish it. The society "Stoomgroep Goes-Borsele" could use such a

building and the contractor was able to deconstruct the warehouse in the given time span and not intervene/interact with the other activities on the building site. In order to remove the building to Goes it was sawn in twelve pieces. An order of all work at the deconstruction and construction site is listed in Table 1.

Table 1: Order of work at both sides

Middelburg (Deconstruction)	**Goes (Re-building)**
Demolition inner walls and ceiling	New foundation
Demolition roof and dismantling steel trusses	
Demolition loading platforms	
Drilling holes for the frames	
Assemble steel frames	
Sawing	
Lifting and transport elements	Transport elements
Demolition foundation	Storage top elements
	Placing lower elements
	Placing top elements
	Placing steel trusses

In the first place volunteers of the society and the contractor would cooperate in this project however the liability and the planning were problematic. The contractor wouldn't take any liability for the volunteers and it was difficult to plan the workload for the volunteers because they couldn't be available for the whole working week. So both parties decided that the volunteers would help in getting started and take over the work after the contractor places the steel trusses for the roof.



Figure 1: The warehouse



Figure 2: Dismantling

The contractor is specialised in moving whole buildings or building elements. The preparation time was very small, only a few weeks, but because the building was straightforward, it was enough. It was clear that the building would be dismantled in elements. The size of the elements was the result of how big the elements could be and still be transportable (Table 2). The size of the building is 29 meters long, 11 meters wide and 8 meters high.

Table 2: The elements and the costs (in Euro's)

Elements	Quantity	Length (m)	Height (m)	Weight (ton)	Sawing	Lifting/ Transport	Steel Frame	Enginering	Total price
Element 1	4	14	4,1	35	1604	8121	9747	1520	20992
Element 2	4	14	1,7	24	1004	6757	7601	1520	16882
Element 3	2	11,6	4,1	35	1505	8121	8629	1520	19775
Element 4	2	11,6	3,8	30	905	7501	8361	1520	18287

The first problem that occurred was that the building was made of bricks and the transport of a brick wall is extremely difficult because such an element cannot undergo any distortion. Otherwise it will be damaged and become unusable. So to avoid damage during dismantling, transport and building a steel frame has been added. The elements have been made by sawing walls, one in every corner and at the long side one in the middle, and one cut at 4 meters high just above the windows and doors. In mean time the foundation has built. The dismantling and transportation of the twelve elements was completed in two days. After placing the steel trusses the job for the contractor was done. At this moment the funds of the society were finished. The society had to finish the building themselves. Firstly they made the roof and the floor. The steel frame has been used for the floor after it was dismantled and so it was given a second lifetime. Finally the new platforms were added so the tracks were lengthened and the trains could stop at the warehouse.





Figure 3 and 4: The first six elements arrived at the building site, the top elements are stored. The last six elements are waiting for transport.

4. FINANCIAL ASPECTS

In this project the contractor was very open with the financial information, but the society "Stoomgroep Goes-Borsele" wouldn't share their information about the finishing touch of the project. This is because that during the project so many costs were made that for finishing the project more funding was needed. This project wasn't finished in April 2002 because they were still waiting for extra funds. The extra money was needed for the roof, interior, the platforms and the heating installation. The total amount available for this project was 413.000 Euro, the amount that was for the work of the contractor was 228.000 Euro. The activities executed by the contractor were all in the offer so the calculation for each element was easy and is listed in Table 2. For the calculation for a new element, exactly the same as the re-used one, is made use of a calculation method that is common in the building industry. The outcome is listed in Table 3.

Table 3: Economical comparison between a new and a re-used element

Element 1 New	Euro's	Element 1 Re-used	Euro's
Bricks & Mortar	900	Cost Element	20922
Labour	2575	Re-use steel frame	1190
Doors	2730		
Scaffold	910		
Engineering etc.	1815		
Demolition old element	1750		
Transport waste	350		
Total cost	11030	Total cost	19732
% new/re-use	56		

All 4 elements are calculated with the same variance. If the building was totally new the amount would be about 400.000 Euro, included the roof, interior, platforms and the heating installation. In that case the building would be better insulated, so less energy needed in the winter for heating en in the summer for cooling.

5. ENVIRONMENTAL ASPECTS.

For the calculation of the environmental load a LCA is being performed. For the comparison between the two elements (re-used and new) boundaries had to be established.

Table 4: what is or is not included in the LCA

	Re-used element	New element
Included	Bricks	Bricks
	Mortar	Mortar
	Doors	Doors
	Scaffold	Scaffold
	Engineering	Engineering
	Steel frame	
	Transport	Transport
	Re-use of steel frame	Demolition old building
		Re-use materials
		Incineration materials
		Landfill
Excluded	Demolition Foundation	Demolition Foundation
	Demolition Roof	Demolition Roof
	Heating and cooling	Heating and cooling

In the LCA is the result of the comparison just the opposite of the financial calculation. This is because all the materials are being re-used. In both cases all the materials are being re-used. But in case of the new element the old element has been demolished and re-used as an aggregate for a road-base and new materials has been used for building the new element. In case of the old element the steel has been added and 90% of the steel has been used for the construction of the floor so only 10% of the steel is processed in the LCA.

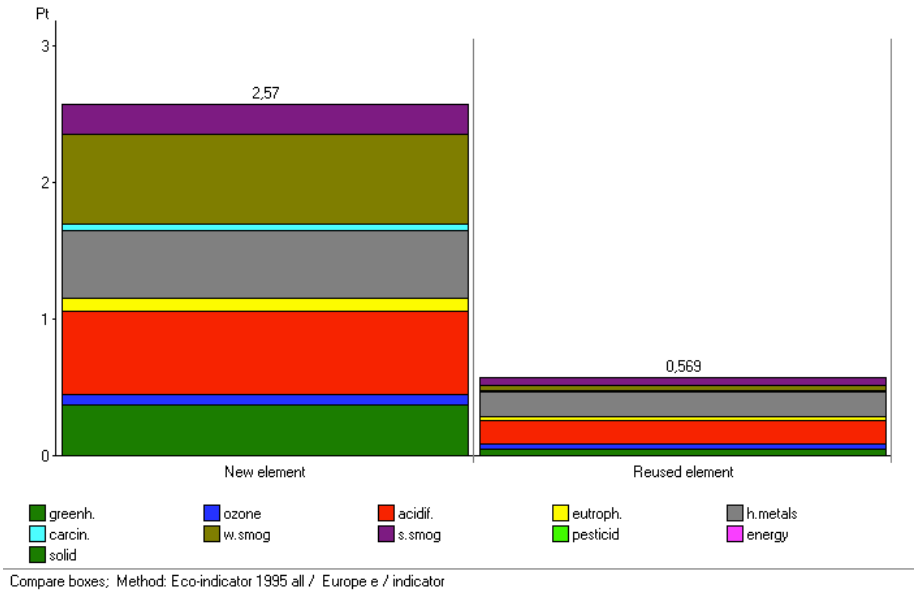

Figure 5: Comparison between the life cycles of the new and re-used element using Sima-Pro

6. CONCLUSION

The operation was a success (technically), no real problems were encountered. Everything went as it was prepared. Just one little problem: because of the height of the elements a detour had to be made. But is has to be said that the building was quite straightforward.
A lot of money has been spent for the re-use. Financially seen re-use is being punished and environmentally re-use is being rewarded. In this case study the building that was chosen was never been built for a dismantling purpose, therefor more money had to be spent to make the steel frame.



Figure 6: After the replacing of the elements it can be seen that it has been a very precise job, the tags are perfectly in place.

This project shows that almost every building can be dismantled, and if it is carried out properly with the secondary elements a new building can be built. But if al the aspects had been included in this case this project would never been carried out, just because the financial aspect is the one with the most importance. And if the environmental load will be given a financial instrument then it could become a deciding factor in designing buildings for the future.

If a comparison is made of the work in this project and the decision support model, it is clear that all steps of this model have been carried out. Firstly the technological deconstruction was possible (no new deconstruction techniques have to be invented). All the (brick) elements were re-used at another place. Financially it was not cheaper to deconstruct and rebuild this warehouse, so a lot of volunteers were making this project possible (financial instrument). This case study makes clear that this model could be used in order to plan deconstruction work in the future.

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Hutsul *grazhda* - wisdom of traditional rural architecture as the guidelines for designing contemporary bioclimatic buildings.

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1. INTRODUCTION

The Hutsuls are an ethnographic group of Ukrainian mountains people inhabiting the slopes of the Eastern Carpathians, mainly in the river-basins of Pruth and Tcheremosh (at the present Ivano-Frankivs'k district, Ukraine). Due to lack of plough-land, the basic occupation of the Hutsuls was cattle and sheep shepherding. Traditional Hutsul dwellings were located mostly at the height of 500-1000 metres above sea level, in the mountains higher than 2000 metres (Tchornohora range). Hutsul settlement was of reclusive character - separate farmsteads were scattered far from each other at the mountainous slopes.

The climate of the Hutsul Lands is characterised with traits typical for mountain regions. Vegetation period lasts 4 to 6 months, depending on the height above the sea level. Summer is warm and sunny, the average air temperature in July is about 13-16°C. Winters are long and frosty (the average air temperature in January is about -5°C). There are relatively strong, south-western winds, year average precipitation is 700-1000 mm depending on the place (in November, December and February more than 110 mm). Snow cover is even up to 70 cm; in top parts of the mountains snow lies even for 4 months. Mountains are covered with old spruce and fir forests, river valleys also with leafed forests. Summits are covered with mountain pastures.

Observations and measurements made in the Hutsul Lands for many years together with the survey of specialist ethnographic literature have rendered it possible to acquire knowledge on the rules and forms of the traditional architecture of this region. In the past, the most fully developed and characteristic form of building was a solitary, wooden, enclosed single-manor farmstead - *grazhda*, which concentrated the whole of the Hutsul farm buildings around the inner yard. It consisted of the typical dwelling room, surrounded by additional rooms (farm sheds for livestock, halls and chambers), covered with the common roof, and the massive wooden enclosure (with their own roof), equipped with tight gate. (Figure 1 and 2b).

This architecture was formed in an evolutionary way with no professionals (in the contemporary understanding of the term), but with using experience conveyed from generation to generation. Due to the fact that traditional rural societies are usually very conservative, also the process of forming architectural solutions used by the Hutsuls was long. *Grazhda* was developed to the form that is known contemporary from research only in the 17th c. or even at the beginning of 18th c. [4,5]. With only minor modifications it lasted up to

the period before WW II. It started to disappear because of introduction of more efficient heating systems and social and economic transformations.

Besides *grazhda*, there were - at the same time - other spatial forms of Hutsul dwelling houses, from the simplest ones (Figure 2a) to those surrounded with additional rooms.

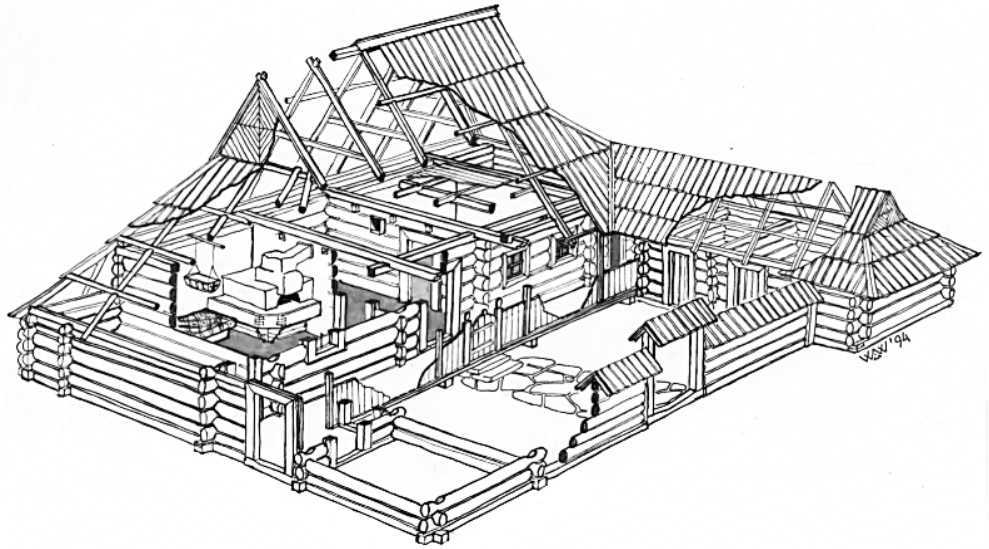

Figure 1. Perspective view of the synthetic example of Hutsul *grazhda*.

2. ENERGY SAVINGS STRATEGIES

The authors defined some characteristic features of the Hutsul *grazhda* that may be helpful in contemporary design of single bioclimatic dwelling houses.

Location:

dwellings protected from winds and snow-storms, choice of the place preceded by long surveys, orientation of the house to the sun, the dwelling harmoniously fitted to natural landscape - colour, surface characteristics, and form - 'non-aggressive' aesthetics.

Form and function:

minimum functional programme resulting from real needs; the spatial form of building resulting from the programme; buffering zones on the North, West, and East sides; gallery in front of the house - summer 'room' and communication corridor under the roof; aerodynamic form of the building, angle of inclination, and form of the roof dependent on precipitation and covering material; window openings on the South side only, optimum size of the openings, window shutters; optimum place for the heating unit; walls made warmer with layers of fire-wood and hay.

Material and construction:

local wood, minimum woodworking - energy saving, durability of wood adequate to local conditions, easy assimilation to the nature after the period of using - enclosed cycle of materials and energy circulation (utilisation, recycling); only local impact on the nature; construction adequate to: physical characteristics of the material, local conditions (climate, wind, precipitation), and functional programme.

Using:

evolutionary process of creation - 'wisdom' of the building as the wisdom of generations; almost enclosed circulation of energy and materials; natural fuel (local wood), using the same heat for heating, cooking, conserving, and storing food; only natural waste.

Initial calculations results obtained for simple and advances Hutsul buildings were presented in previous work [3]. They inspired and encouraged the authors to make further, more precise analyses.

In this paper important role of additional rooms and the front enclosure for wind reduction and heat transfer through the walls was confirmed. The differences in results of heating energy demand and internal temperature for two types of Hutsuls houses was presented.

3. TWO MODELS OF EXEMPLARY HUTSUL COTTAGES.

Advanced numerical techniques were used to confirm an ecological character of Hutsul buildings and authors' main thesis pointed above. The geometrical models of two synthetic examples were created within ESP-r advanced building simulation program based on mathematical model proposed by Clarke [2]. Simple Hutsul cabin and *grazhda* were established as a multi-zone thermal system represented by several control volumes described by their geometry, construction and operation. Both the models are theoretical but all the data were taken from typical Hutsul buildings. They were obtained from available literature and architectural measurements made by the authors [6,4,5].

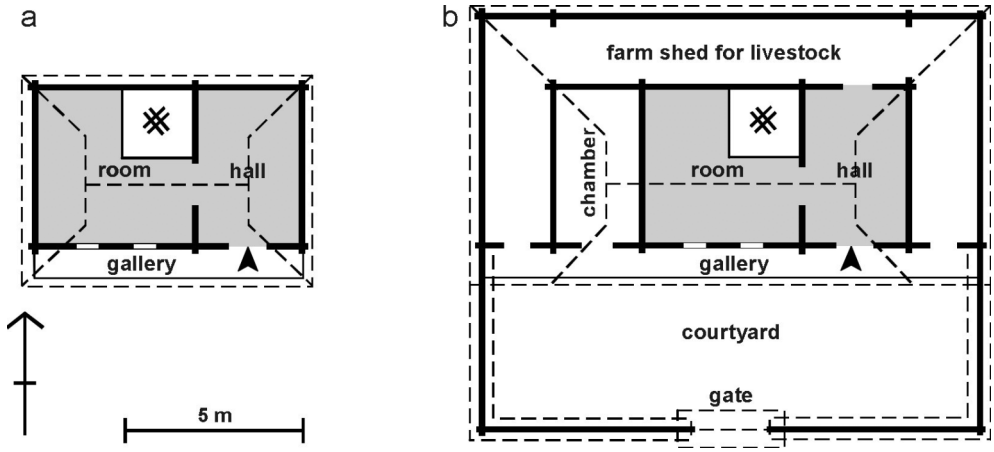

Figure 2. Schemes of plans of selected types of Hutsul houses chosen for calculations: a) simple cabin b) *grazhda*

3.1. Geometry.

Simple cabin and *grazhda* (Figure 2) were modelled separately within ESP-r program. The three-zone major part of the buildings, consisting of the room, the hall and the under roof space, is common in both the cases. In *grazhda*, two extra zones – farm sheds for livestock and the chamber – surround the room and the hall and separate them from external environment. The main room is 4.5m long and 4.5m wide, with two windows in south external wall and it is the only dwelling space in the building. The room is connected with exterior by the hall as a buffer space with two doors: one from the hall to the room and the other one from the hall to the outside environment.

3.2. Construction and materials.

Due to local source of construction materials, only wood was used to construct Hutsul buildings. The external and internal walls were defined as a homogenous timber wood construction with an overall thickness of 13.5cm and 10cm, respectively. The ceiling over the room and the ground floor were wooden as well but there was no ceiling over the hall. Thin and leaky wooden tiles (long shingles) covered the roof space. Temperature below 0°C on external wall surface for *grazhda* allows taking into account additional snow layer. It reduces the value of heat transfer coefficient and protects against heat looses through the walls. We

cannot do the same assumption for simple cabin, where the external surface temperature above 0°C causes melting of the snow layer, which is in contact with the wall.

3.3. Operations.

The internal heat gains for the zones were the source of uncertainty. According to the authors' experience, about six persons, at the average, lived in the building. For the simulation, we assumed six persons staying in the room during the night and four persons during the day. Additional energy inputs from animals were defined in farm shed for *grazhda* only. The room, the hall and the under roof space were connected to each other and with external environment by ventilation network. The magnitude of the network component and type of connection were estimated from the authors' measurements. Only small gaps between the zones and the exterior (cracks between each timber-woods beams or around the windows) and some openings inside the building were defined but their size was another source of uncertainty. There was no direct airflow connection by the door from outside to the room (because of the hall). The buffer spaces around the room exert a real influence on infiltration. The number of air changes per hour is two times smaller for *grazhda* then for simple cabin but it is still not less then 0.4 – 0.6 ac/h.

Typical Hutsul chimneyless stove was built from a clay on the wooden frame. For the simulation, we assumed 2.5 kW heating unit in the room. The heating unit works periodically from 8:00-10:00 a.m. and 4:00-9:00 p.m. and, as we expected, it should guarantee internal room temperature between 10 and 15°C as the effect of its high thermal mass.

3.4. Boundary conditions.

Unfortunately, no realistic climatic data for any Eastern Carpathian region are available for the authors. That is why it was decided to choose the relatively similar period of one week from realistic weather data for Poland. The period from 15 to 21 of January was selected, as it consisted temperature, direct solar radiation and wind speed similar to the monthly averages in the Hutsul Lands [1].

4. SIMULATION RESULTS AND ANALYSIS.

Indoor resultant temperatures were calculated for every zone in the building. The maximum temperature difference between the room in *grazhda* and the room in simple cabin was about 2.5K during the night and 2.0K during the day (Figure 3a).

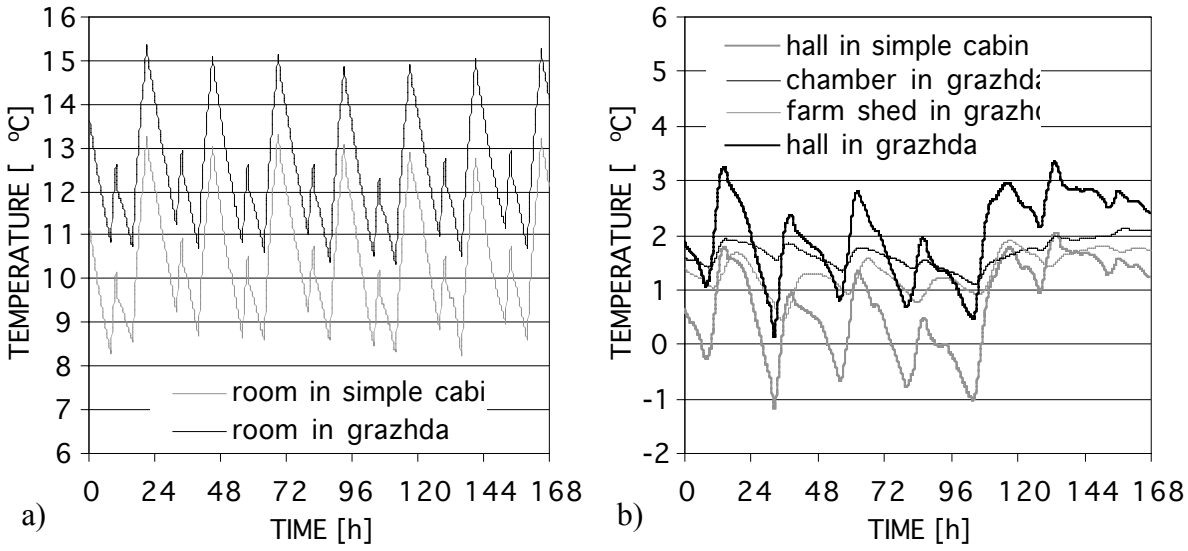

Figure 3. History of internal resultant temperature in selected zones.

Percentage temperature distribution in the dwelling room (Figure 4) shows much better thermal comfort conditions for *grazhda* (resultant temperature over 12ºC during 50% of test period) then for simple cabin. On the other hand, the heating energy coming from the room is utilised in buffering zones as well and allows to keep their temperature over 0ºC (Figure 3b).

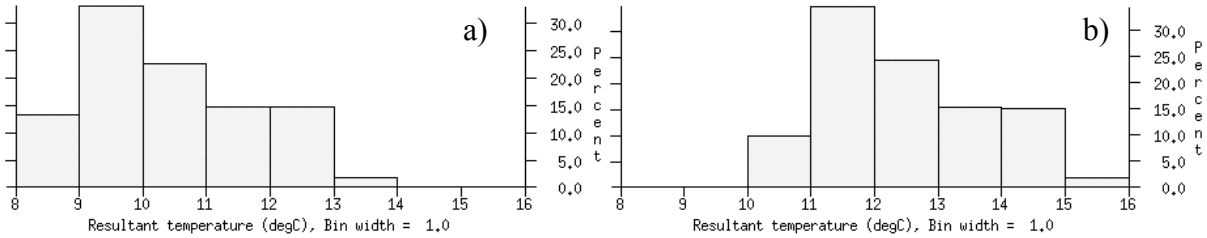

Figure 4. Room's resultant temperature frequency distribution for a) simple cabin and b) *grazhda*.

It was noticed that heat conduction through the room's walls is 40% lower for *grazhda* then for simple cabin (Figure 5b). Also infiltration through the walls and roof was reduced to 60% owing to more aerodynamics shape of *grazhda* (Figure 5a). All the results above show that the buffering spaces around the room have a great impact on heat conduction through the wall and infiltration rate.

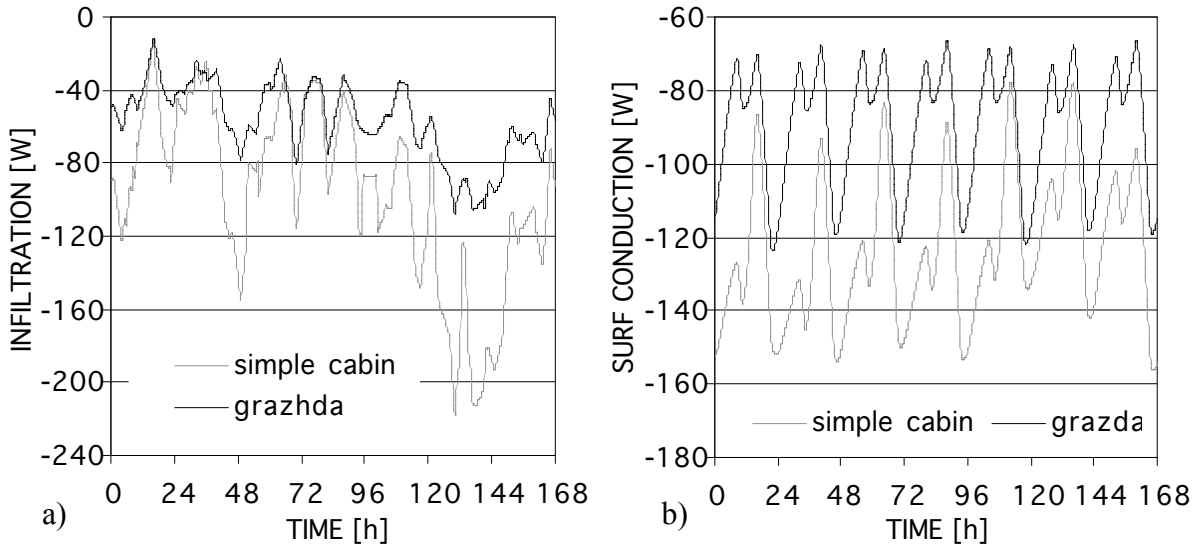

Figure 5. a) Infiltrate heat flux and b) Conductive heat flux through west wall in the room

If we extend heating period for simple cabin to reach the same value of mean temperature we can estimate the differences in energy consumptions in both the cases. As it was expected, we have about 22% less energy consumption in *grazhda* then in simple cabin. However, there was no fuel limitation in the Carpathian region. That is why we are almost sure that better indoor quality was more important for the Hutsuls than reduction of fuel consumption.

5. CONCLUSIONS

Results of computer simulations for selected period of January show that simple solutions and experiences, conveyed from generation to generation, helped the Hutsuls create the most efficient building system as possible. Only a few guidelines were analysed but obtained results let us formulate the conclusions below:

5.1. For the same, additional, external source of energy (limited to 2.5 kW power heating unit), resultant temperature in grazhda is higher then in simple cabin about 2.0K during the day and 2.5K during the night. It allows us to reach higher thermal comfort for dwellers in grazhda, then in simple cabin, with the same amount of energy consumption.

5.2. If we equal heating set point for grazhda and simple cabin to the 14.5ºC (maximum value allowed to achieve in cabin with 2.5kW heating unit) the real savings in energy consumption are provided to be about 22%. However one week is too short period for such kind of conclusion; future analyses, for whole heating season with more realistic climatic data are necessary.

5.3. Relatively high thermal mass of fireplace reduce daily temperature fluctuation to 5-6 K, although heating unit is turned off for 10 hours during the night.

5.4. Additional external zones (farm shed and the chamber) protect against the wind and give the real savings in energy loosing for infiltration and heat conduction through the room's walls.

Moreover all changes in building structures during the evaluations were done in accordance with natural environment. There were no aggressive influences on surrounding, energy sources and materials. Neither advanced calculation technique, nor active energy systems were used in Hutsul buildings. On the other hand, only passive techniques allowed reducing energy consumption more than 20%. It proved that passive systems are sufficient enough and can be used regardless of localisation and environmental conditions, which is very important

in developing countries. Because of the great potential of passive technologies philosophy works with, rather than in spite of, the local climate should be preferred.

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Systematically approaching integration of building environmental qualities

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1. PROJECT INTRODUCTION

Vest-Agder fylkeskommune (county / owner) is building a new school in the city centre of Kristiansand, in Southern Norway. The project includes a total new-building area of 9.300 m^2, and a refurbishment area of 10.700 m^2, for a total of 20.000 m^2.

The overall project period started spring 1999 with an architectural competition, and is scheduled for completion in summer 2003.

The project is supported by the Norwegian EcoBuild program (Økobygg).

2. POLITICAL DECISION

Vest-Agder fylkeskommune (VAF) is a pioneer in formulating an administrative environmental decision document, approved by the politicians, focusing on Eco-building principals when planning, building, refurbishing and operating buildings. VAF totally administrates 150.000 m^2 of buildings, and plays an important role as a governmental facility owner and manager. Therefore VAF is an importing drive-force by setting requirements for example for area- and energy efficiency and -flexibility, material usage, indoor environmental qualities and waste production. A very important political statement opens up for qualities with higher investment costs, if a lower life circle cost is documented.

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3. PRE-PROJECT ACTIVITIES

3.1 New-building contra refurbishment

Originally the school complex consisted of two building generations of totally 20.000 m2, the older from 1957 and the newer from 1974. The older building included workshops and classrooms not practical for modern education programmes. Two alternatives were discussed: New building contra refurbishment. A step-by-step method for estimating investment costs, life-cycle costs and environmental impacts and potentials was developed. Based on this study the new building alternative won both with respect to cost and environmental aspects.

3.2. Demolition

The older 5-floor building, constructed basically in concrete materials, was demolished according to the very best waste handling methods with regards to special waste, materials sorting, re-use of components etc. The main measure that less than 5% should be deposed was formulated. This project was very successful: More than 98% of the total building weight was re-circulated in different materials.

3.3 Architectural competition

Four (4) main criteria regarding environmental aspects were given in the competition rules:

- Building body and technical systems design with respect to optimal energy usage.
- Natural or hybrid ventilation to be preferred if environmental and economical profitable.
- Utilising of day lighting, sun energy and rainwater.
- Material usage to be evaluated with respect to production, transportation, assembly, usage and end-of life qualities.

Three (3) different architect proposals ended up in the final round, and were evaluated against given criteria also involving environmental aspects. A simple balanced score method was developed for evaluating the Eco-building potential considering several conceptual parameters like:

- Location of school related to existing infrastructure
- Impacts from the city environment
- Building location on construction site
- Building potential for utilising local climate (wind, temperature, sun etc)
- Building integration with existing buildings and the outdoor environment
- Concept results related to area flexibility and -efficiency
- Climate zoning and body design
- Materials usage (qualities, prefabrication rates, de-construction potential)
- Low energy potential focusing ventilation system, day-lighting, air condition etc.
- Water and waste water systems

In addition to the Eco-building potential related to technical design, the architect's competence and experiences from previous projects was evaluated.

Evaluation of totally 59 parameters was summed-up to a total score. In this project the winner of the Eco-evaluation also won the architect competition.

3.4 Contract form and organisation model

The contract is organised according a new partnering model developed by VAF and Tet AS[1] (consulting company acting on behalf of the building owners). A partnering organisation named "Kuben"[2] was established as result of a tender competition, based on the architect winner concept, where three criteria formed the basis for evaluation: (1) Will and ability to work in a partnering setting (counts 40%), (2) competence (35%) and (3) price estimate (25%). A win-win model has been developed through several phases of planning and design. During the pre-design phase a target cost was defined based on corresponding definition of quality, also including environmental qualities. Both cost reductions and cost-increase are shared in solidarity.

A partnering organisation consists of the complete group of consultants and entrepreneurs taking full responsibility for the completion of project jointly with the owner and users, from day one.

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[1] Tet AS. Vestre Strandgt 23, 4666 Kristiansand, Norway. Phone +47 38 07 46 39. E-mail: post@tetas.no.
[2] NCC Norge AS, Unico AS, Cubus Architects, Sønnico AS, GK Sørlandet, Vest-Agder fylkeskommune (owner) and Kvadraturen vgs (user).

4. ENVIRONMENTAL MANAGEMENT METHODS

4.1 Environmental management program

An Environmental Monitoring Program was formulated by the Builder and made effective from the overall project start. The monitoring programme includes owner's visions, strategy formulations, objectives, targets and actions.

In addition a quality assurance program is developed, also including the environmental aspects of quality.

4.2 Study program

A number of approximately 50 studies covering important building qualities have been performed, involving the partnering organisation. Many qualified personnel (architects, consultants and entrepreneurs) with different experience have developed creative and practical solutions. Three areas are focused; (1) technical / functional, (2) economical (life cycle costs approach) and (3) environmental qualities related to natural environment, resources and indoors climate. Eco-building qualities are evaluated against life cycle costs, forming a basis for decisions, whether the proposed action shall be adopted or not.

4.3 The M3P-method[3]

This project has been a pilot for testing new techniques on formulation of measurements and actions to obtain sustainable building qualities in a prioritised way. The results from the M3P processes are incorporated in the Environmental Monitoring Program.

4.4 LCC and Eco-efficiency

Decisions on if a potential environmental actions shall be applied or not depends on two factors:

- Is the total environmental efficiency positive or negative?
- Is the total life circle effect positive or negative?

If both factors are positive, the action will be implemented, and not if both are negative or if there is negative Eco-efficiency. This is illustrated in figure 1. In square II a political decision must be taken. A calculation tool corresponding to this model is developed.

	Positive LCC	Negative LCC
Positive Eco-efficiency	(I) Implementation	(III) Political decision
Negative Eco-efficiency	(II) No implementation	(IV) No implementation

Figure 1 LCC and Eco-efficiency matrix.

4.5 Interactive e-learning

Vest-Agder fylkeskommune has introduced a new web-based interactive multimedia e-learning system developed by Ecobas AS[4]. The system is a complete "Eco-building school" consisting 25 modules approaching thematically most aspects discussed by architects and consultants, entrepreneurs and workers, and operation personnel. The learning programme follows the building's life from cradle to grave.

E-learning is a most efficient and cost-reducing method. Learning can be executed at work, at home or anywhere. The learning is followed by examination, and a diploma generated with

[3] M3P (method for environmental measurements and priorities)
[4] Ecobas AS (see www.ecobas.no for more information)

successful results. As the education programme is Internet-based, links are established to relevant regulations, technical descriptions and supporting information of any kind.

The program consists of pictures, drawings, animations, simulators, video, text and voice, and is a modern multimedia program that is engaging, involving and motivating.

The first modules produced were directed to the entrepreneurs and workers at the construction site: (1) Clean building, (2) Dry building and (3) Waste handling.

4.6 Environmental accounting system
An accounting system has been developed divided into the following sections:

Account No series	Name	Phase reflected
1.	Building design characteristics	Design, operation
2.	Construction phase characteristics	Building
3.	Operational phase characteristics	Operation, maintenance, refurbishment
4.	End of life characteristics	End of life

The accounting system contains both budget and account modules, also calculating deviations per account number periodically. Aspects related to material usage, energy usage, waste production, water consumption, climate gas production are focused.

4.7 Materials evaluation
Two studies are focusing on material selection: (1) Principals and (2) Procedures for declaration and evaluation. The first is focusing on materials requirement in general environmental terms as ecological and health properties, resources, maintenance, cleaning, resistance for wear-and-tear and damages and level of prefabrication.

The second study report concludes with a method for declaration, evaluation and choice of materials. Several methods are evaluated, most of them are characterised as complicated and based of a comprehensive declaration form which is still does not exist from the suppliers. Our step-by-step method, however, also requires a declaration focusing on chemicals and emission data having health impacts. Low-emission indoor materials (flooring, walls, ceilings and interiors are of high importance, also due to the low-flow rate hybrid ventilation system.

4.8 Eco-data sheets
The most important Eco-building qualities are described in so-called Eco-data sheets (1-page each action). The format is simple: (1) main motivation, (2) technical introduction, (3) Eco-efficiency and LCC results summary, (4) scope, (5) references to other documents (study reports, drawings, calculations etc) and (6) responsible contact. These Eco-data sheets are valuable for future projects and decisions.

5. RESULTING AREAS

5.1 Hybrid ventilation system
A hybrid ventilation system has two mode operation possibilities.

i) Driven by natural forces, stack effect and/or wind
ii) Fan assistance on the supply air distribution or on the extract air distribution or both.

The "Specific Fan Power" coefficient (SFP) for a hybrid ventilation system is typically in the range between 0,10 – 0,20 (kWs/m^3), compared with typically SFP = 2,5 – 3,0 for a conventional mechanical ventilation system.

Consumption of electric energy for running fan motors are considerably higher for mechanical ventilation systems (high pressure systems) compared with hybrid ventilation systems (low pressure systems).

5.1.1 Motivation and feasibility study. The tender competition program encouraged energy effective and environment friendly solutions. If technically and economically possible, natural ventilation should be utilised. There were several challenges. The buildings are located in the city centre, with some pollution from cars and buses during peak hours. The new-building will have five levels above street.

Kuben appointed Byggforsk (The Norwegian Building Research Institute) to participate in a feasibility study. Basic natural ventilation was rejected. The study resulted in a presentation of four possible hybrid ventilation concepts. The four different concepts were evaluated and one solution was recommended, as described later. A risk analysis was performed based on a comparison between the recommended hybrid ventilation system and a conventional mechanical ventilation system.

5.1.2 Capacities. To minimise the ventilation rate, several considerations were made.
- Documented low emission materials to be selected.
- Easy-cleaning design.
- Displacement ventilation.
- High quality glass and venetian blinds.
- Demand operated ventilation rates to areas/rooms with varying loads.

However, the fact that several classes having polluting activities as welding and car repair, and that some students use dirty and oily clothes, will give an increase of the ventilation rate.

The maximum capacity of the air handling units are calculated to 25 m^3 /s. The gross area of the actual new-building is approximately 8.500 m^2 .

5.1.3 Principal and detailed design. Outside air is taken close to the roof level on two sides, North and South, through louvers effectively draining water before air entering the filters. The fresh air is filtered through a large surface filter at low pressure drop. The air passes a heat recovery coil, connected by pipes pumping fluid to similar heat recovery coils located on the roof. If necessary, the filtered and pre-heated ventilation air is re-heated by aerotempers.

If needed, the pressure of the ventilation air is increased by frequency controlled axial fans, operated on basis of the static pressure in the main duct. The main duct, made of concrete and surrounded by sand, runs under the entire building. The total exposed surface of the duct is approximately 600 m^2.

During summer conditions, some cooling effect is expected. The ventilation air then runs in vertical concrete shafts. The shafts are also a part of the buildings structure. The shafts are connected to each area by horizontal ducts in a modularised pattern. Used air is extracted from each area to separate vertical concrete extract shafts. The extract air is exhausted, via heat recovery coils, on the roof. Several frequency controlled axial fans maintain balanced air flow.

Each major area room is monitored by CO_2 sensors. The CO_2 concentration indicates the activity level and density of the population, and the ventilation rate will be automatically adjusted accordingly by modulating dampers.

5.1.4 Results and conclusions. The hybrid ventilation system for Kvadraturen school was compared with a conventional ventilation system with the same performance. Capital cost, maintenance cost, re-investment cost and running cost were compared. The analysis show that hybrid ventilation has some 7% less expected annual cost compared with a conventional system. The main reason for this result is less running cost (energy cost).

5.2 Pedagogical aspects

As Kvadraturen school is a secondary school for vocational education, the environmental qualities of building body and technical systems is of interest, but also motivated from the fact that the youngsters may learn about essential environmental aspect and impact caused by the building industry and the operation of buildings.

5.2.1 Consumption and capacities. Energy and water consumption is continuously measured, monitored and displayed, also the waste production. Technical systems functions are logically displayed. Computer operation of systems enables adequate data collection.

5.2.2 Building design. Key words are: Construction methods. Material and design qualities. Regulation of ventilation and heating. Operations influenced by the user.

5.2.3 Health. Indoors bicycle parking area with direct access to shower and training studio, canteen serving ecological food products, indoors environmental qualities etc.

5.2.4 Eco-School certification. The school is certified by the international Eco-schools body, operated by Foundation for Environmental Education (FEE), qualifying for the Green Flag[5]. First year certification is based on a project focusing local climate registrations, used as input values for building design. Next year's Eco-Schools project is related to the health program.

[5] FEE Norway (see www.fee.no)

5.3 Materials usage
Natural materials are preferred if preferred from an environmental interest; low emissions, chemicals, low waste rate, extended lifetime, and easy assembly and de-assembly.

5.4 Facade design
Integrated facade design parameters were early introduced and discussed, having impact on several study reports. In practice the discussions involved glassing, building body design including heat transfer and insulation.

5.5 Water supply and waste water system
The pre-engineering design included a separation of "grey" water and "black" water. The intention was to clean the grey water in a neighbour park and re-circulate. Later this was rejected.

Surface water collected on the roof, is separated and run in separate pipes to a 15 m^3 storage tank located under the school yard. Sand is separated from the water. The water is pressurised by pumps and will be used to wash cars and the school ground.

5.6 Construction
Neighbours are informed regularly on building design, schedule and special processes, i.e. spunting, transportation etc. Open meetings have been arranged and brochures are produced.

Silent construction period is an important measurement. The noise level is measured and reported related to special processes. A new silent-spunting method is used. Gliding reinforcements are used during concrete work on the main building shell. A target of zero neighbour objections is set.

Other main focus areas are: Dry and clean building procedures and waste minimising and fractionalising.

6. CONCLUSION
This project has a wide and multiple approach concerning eco-building qualities. New methods, tools and technology have been developed and used. Our conclusion is that the eco-potential within the building industry is still comprehensive. The introduction of the partnering organisation model is an essential success criteria to release this potential by competence, co-operation between disciplines, common goals and economical incentives.

Discursive Features of Sustainable Building in Media

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1. INTRODUCTION

Media exert an individual and collective influence through "agenda setting" (Anderson 1997). Thus the media do not tell us *what* to think but set the agenda of what issues to think *about*. Medias impact on public attitude is also increasing if the public is repeatedly exposed to messages advocating a particular view (Eagly and Kulesa 1997). It is therefore reasonable to assume that media work as a 'silent' influencer through the common debate about sustainable building. This is also confirmed by the following statement by the CEO of a large Swedish construction company (Öqvist 1999):

"[Project X] was never an environmental scandal, it was blown up to be one by media."

Actors in the building industry obtain information concerning sustainable building from easily accessible sources, such as trade magazines (Femenías in press). The actors seem to have difficulties adapting to new scientific research since they never or seldom read research reports or scientific articles (Femenías in press; MiljöRapporten 2000). As a well-reputed Swedish architect expressed it:

"We frequently read a great deal of trade magazines and expect, of course, that research results are reflected in the trade press."

Since evaluations of demonstration projects in most cases are presented in research reports, the knowledge about, attitudes towards as well as behaviour connected with sustainable building are partly dependent on the discourses in trade magazines. This motivates the present study, which is to explore how the media convey results from demonstration projects. That is projects with a formulated ambition to be in front-line considering development of sustainable building.

Qualitative content analysis, an inclusive representation of patterns found in a corpus, was used as a method to describe media's representation of sustainable building (Thompson 2001). Articles concerning three well-known Swedish demonstration projects carried out during the 1990s, Ekoporten, Understenshöjden and the Sunhouses in Gårdsten, were reviewed for in four Swedish databases[1]. That these projects were completed, driven by the client (the building proprietor), have been or will be evaluated (Botta et al 1999; Dalenbäck 1999; Levin et al 2000) and that learning experiences from these projects are intended to be transmitted to forthcoming building projects served as criteria of selection. Articles, about the demonstration projects, published in trade magazines constitute a corpus of 24 articles[2], which was analysed according to author, source, text type, tone, main topics, purpose of the article, sustainable themes and terms, and knowledge content.

[1] Presstext, Mediearkivet, Byggdok and Artikelsök
[2] A list of the articles selected for analysis is available from the authors.

In this paper we discuss how a number of Swedish demonstration projects have been presented and debated in selected influential Swedish trade magazines. We ask two questions: *What function does media fulfils as information carriers for sustainable building?* and *How is sustainable building presented in trade magazines?* The aim is to explore media's conveyed image of sustainable building and to reflect upon how this image may affect sustainable development of building practices.

2. INTERPRETED FEATURES AND CONTENT OF THE ARTICLES

Most articles in the corpus were reports written by journalists and few provide argumentative or analytical information to the reader. Short interviews were the most frequently occurring direct source. More than 40% of the articles in the trade press do not mention any specific sources. Articles written by persons involved in the building process often rests upon their experience. In other cases, where no explicit source was mentioned it was, by looking at phrasings and use of vocabulary, possible to reveal that much of the material conveyed in the articles were collected from a limited number of original sources. These sources were, often found to be information material supplied by the project developer (owner, initiator). The authors seem to strongly rely on their source and do not reflect nor question the veracity of the matter. This implies that a majority of the articles have a positive undertone and thus seldom provocative to the matter in hand. More critical articles are found when negative results from evaluations are presented after the project has been completed.

Two main purposes can be detected: promoting and informative. Promotive articles are 'selling' either the demonstration project as a good example, or environmental concepts used in the demonstration project, or even an actor, often a fiery spirit, involved in the project. Most informative articles describe technical systems, give background information to the demonstration projects accomplishment or provide information about the results held from evaluating the projects.

Only approximately one third of the articles provide based on our judgement as civil engineer and architect, the building industry with valuable knowledge that can serve as exemplification, information or inspiration for future environmental decisions. The knowledge content mostly involves examples of technical measures and solutions used or to be used in the building project. Others provided knowledge concerning: evaluations of the demonstration project, examples of solutions to social problems, causes to problems that appeared through the process in making the building environmentally sound, and issues regarding communication and cooperation. Articles with less valuable information are either too general (for example in Bengtsson 2000a; Jerström 1997), or focusing on more daily matters than on building or building process related issues (for example in Karlsson 2001; Lindgren 1998). Others provide ambiguous or at least biased information, as in articles about Gårdsten were two promoters of the project figured as main spokesperson in 6 out of 8 articles. In addition, comparing the knowledge content in the articles with the original source, several misleading errors can be found. Ignorance and misinterpretations can be identified as the main cause of these errors. For example some technical solutions, as sun-panels, are taken out of their context and described as energy reducing just by being technical solutions. Also falsely cited researchers and research reports occur. Articles most critical towards sustainable building in the corpus, were for example based on a falsely cited researcher (Nordling 2000). It was stated that the buildings were subjected to moist and mould problems caused by poor design. This rendered in headlines as: *Understenshöjden, rich on moist and draught* (Bengtsson 2000b), *Environmental ideal questioned* (Lundholm 2000), *Fiasco for honoured ecovillage* (Westmar 2000). That this one false citation in one article (Bengtsson 2000b) was

repeated in at least eight other articles, published in trade magazines or daily newspapers and written by eight other authors, witnesses how uncritically data is published and how unreflecting the authors is towards their source.

3. THE CONVEYED IMAGE OF SUSTAINABLE BUILDING

Figure 1 shows that a large number of different actors figurate in the articles. Nevertheless, only a limited number of persons are cited or in another way active in the articles. These *solitary* spokespersons are usually represents from the client or actors engaged by the client such as researchers or consultants. Often these persons are fiery spirits with a lot of engagement for the project. The articles focus on design and briefing and later the operational phase (with evaluation) why spokesmen for the construction industry are seldom cited.

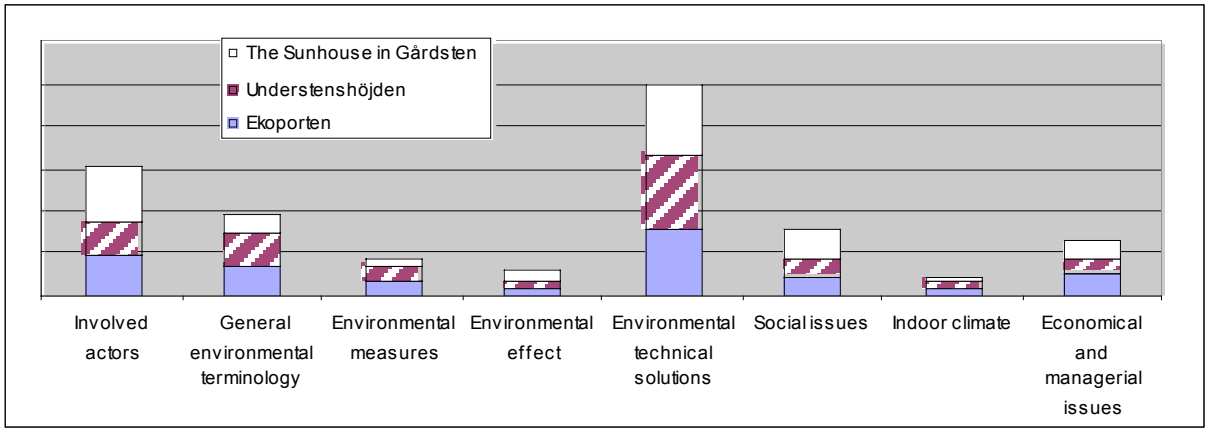

Figure 1: Key subjects involved in the discourse of sustainable building

The study clearly indicates that the corpus describe sustainable building as foremost a technical issue with the emphasis on technical solutions. These technical solutions and systems are often related to, and sometimes even interwoven with environmental issues. Except for technical solutions, are environmental issues most often presented in general terms using a nomenclature characterized by indistinct and fuzzy words. Words as for example environmental, green, ecological, eco, natural, environmental friendly, and sustainable are compounded with words as building, construction, living, adjustment, behavior, habits, perspective, and attitude. By using undefined terminology the authors rely on already established pictures and (mis)apprehensions of sustainable building. In line with the common perception of sustainability, social issues, concerning the human sphere and the living environment, is well represented as part of the discourse of sustainable building. Important to notice is that both Ekoporten and Gårdsten are refurbishment projects of buildings located in socially degraded suburban areas, which probably contributed to this emphasis in the articles. Issues regarding the economic dimension of sustainability are difficult to discern from the articles. When the economical issue come up it mostly evolve increased investment costs, received subsidies, or residents' decreased costs due to individual control of electricity, heating and water use. More often managerial issues are mentioned as part of the sustainable building discourse. While social and technical issues are used as arguments advocating sustainable building, economic and managerial aspects of the building process are perceived as the main cause of failure. Problems concern a variety of aspects, such as organisational, economical, coordination, communication and conservatism. A number of contradictory images, tensions, are depicted in the corpus. For example both cost savings and non-profitable activity are mentioned in the same article without reflections (Kretz 1998), as well as marketing effects and experimental effects not possible to duplicate (Bergdahl and Svane 1998). Technical contradictions involve the use of techniques for renewable energy versus the

claim that the design used in demonstration projects are 'consuming' more energy than conventional buildings (Botta 1999; Snis 1998). Two causes to this occurrence of tensions can be identified: The author has taken a prejudgment and sticks to it by finding arguments that support this position. Secondly, the sustainable building discourse is sensitive towards trends and the author forgets about the context of which the building was accomplished and conveys it according to a view perceived at the time of writing. For example projects accomplished in the mid 90s, when eco-cycles was emphasized in the common debate of sustainability, are judged upon their energy use in the late 90s when energy is seen as an important aspect to consider.

The list[3] of five environmental stake areas considered as most important for the building sector to achieve measures within (The Ecocycle Council of the Building Sector 2001), are used to distinguish the environmental aspects highlighted in the articles.

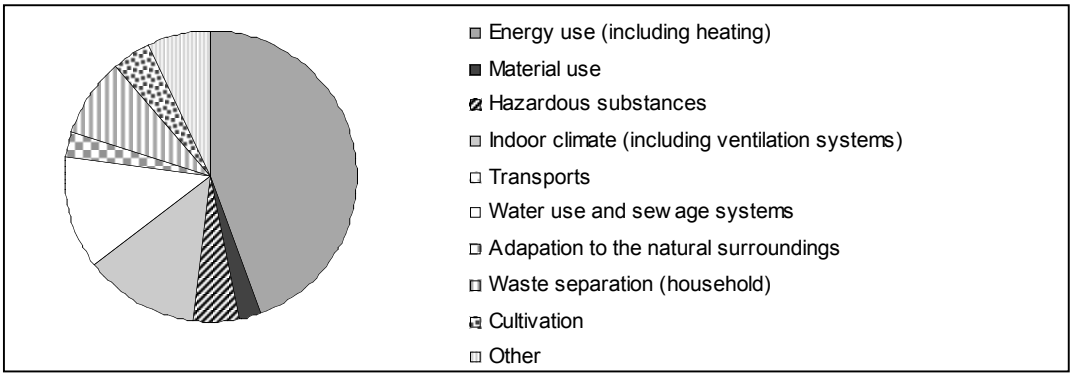

Figure 2: Environmental aspects considered in the corpus

As illustrated in Figure 5 the reduction of *energy use* during the usage phase and use of renewable energy resources is the main issue in all three cases. Negative results regarding energy use are lively debated. Actors involved in the building or evaluation process have been cited, explaining that the reduction of energy use have not been the highest priority on the agenda in the programming of the project (see for example Snis 1998). Regarding *material use* during the construction phase and the usage phase, the intention to reduce the amount of materials used is not explicitly mentioned as a measure in any of the cases. The sorting of building waste is only briefly mentioned in two articles. Some materials are vaguely said to be "eco-cycle adapted". Often focus is on choosing environmentally 'correct' materials, also called environmental friendly, reliably tested, "natural" or healthy materials. Implicitly understood as either *material without hazardous substances* or materials developed with environmentally adapted technique, often not specified which. The criteria for choosing materials are not well accounted for and the specific quality attributed to the materials remain vague. In articles about Understenhöjden aesthetics are mentioned as a criteria for material choice. Only one article mentions *transports* of any kind. Implying that that transports of building material is not regarded as an important issues in the articles and probably not in the projects either. *Indoor climate*, is brought up as an important issue in several articles. Some point at more specific considerations, such as creating climates free from emissions and allergenic substances as well as reducing influence of electromagnetic fields and noise while other articles approach this issue in more vague terms as "a good indoor climate", houses that "breath" etc.

[3] The stake areas are: Energy and material use, use of hazardous substances, indoor climate, and transportation of building material

Some sustainable themes mentioned in the articles are not covered by the list made by The Ecocycle Commission for the Building Sector. For instance, the objective of locally closing-the-loop during the operational phase, for example sewage systems with recycling of nutrition and infiltration of rainwater. Furthermore, waste separation/compost and cultivation are other issues mentioned as environmental measures. Articles about Understenshöjden also emphasize the projects ambitions to adapt the building to natural surroundings.

The problem definition concerning environmental load from the buildings are missing in all articles and specific reasons to why certain ambitions and environmental solutions have been chosen in the demonstration projects are not provided the reader. Reasons as bad maintenance, poor thermal aspects and social problems are not easily connected to the solutions given (see for example Karlsson 2001; Silén 2000). In addition experimental effects (see Bergdahl and Svane 1999; Botta 1999) are 'justifying' made priorities. This whole study has revealed that the environment serve as a sub-ordered aspects in the discourse of sustainable building. Either the effects upon nature and environmental aspects are considered as well known and thus are taken for granted or environmental aspects of building is not fully identified and thus ignored in the articles.

4. REFLECTIONS AND TENTATIVE CONCLUSIONS

The image of sustainable building given in the articles is largely dependent on the ambition and focus of the projects, which is communicated through only a small number of involved actors and written sources. This implies that a few persons' opinions to a large extent influence the agenda of future development of sustainable building. An over dependency on the image given by media therefore may result that incorrect perceptions are established and if often repeated accepted as the "truth" causing stagnation in the development of sustainable building.

Most articles convey too general, biased, and non-reflective information of sustainable building. This may imply that decision-makers involved in building may not comprehend why environmental aspects are important to consider and thus are unable to identify relevant environmental problems and foresee the consequences of their decisions. The bias towards technical solutions and the scarcity of problem definitions regarding environmental loads may result in an increased emphasis on already defined "environmental solutions". This implies that benefits held from other issues, for example process improvements, are neglected and entails distorted allocation of resources and means. In addition, the focus on experimental effects held from demonstration projects may mediate an image of sustainable building as a passing trend, characterized by conspicuous and 'selling' attributes, and thus not of importance other than serving as 'reputation management'. It can be questioned whether or not trade press are entitled to serve as an appropriate information carrier for sustainable building. Either the industry must rely on other non-biased information sources or the trade press must improve their quality. However that may be, it is important that researchers, when communicating research results, are over-explicit in order avoid being misinterpretations. Furthermore, tensions in the articles indicate that there exists no uniform definition of sustainable building.

This study indicates several gaps to perform research within. For example how the building industry manage environmental aspects and how they perceive sustainable building. To make more definite conclusions of the image conveyed by media and its influence on environmental decisions made by actors involved in the building process, this study must be evaluated more extensively.

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Criteria and Indicators for Environmentally Sustainable Construction and Housing - An ongoing research project in Germany -

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INTRODUCTION

By consuming energy, materials, and land, construction and housing is responsible for a considerable proportion of environmental burdens in a densely polulated, industrialized country like Germany. Therefore, this field of action has key importance for sustainable development.
The German national sustainability strategy adopted in spring 2002 highlights the prime trends in economy and society, and traces on this basis the necessary course towards sustainability. Furthermore, it designs a vision for sustainable development and presents a set of goals and indicators for the country. In a second part, the programme of action, it sets out as far as possible the necessary concrete and practical steps.
Among the environment-related aims mentioned in this sustainability strategy, the need to reduce resource consumption and land use is emphasized besides climate protection:

- By 2020, energy and raw material intensity is to be reduced by around half in relation to the levels of 1990 and, respectively, 1994. Through this, resource use will be reduced in absolute terms, too.
- The climate protection policy of Germany aims to reduce the emissions of the principal greenhouse gas CO_2 by 25% by 2005 in relation to 1990. A drastic reduction in present greenhouse gas emissions is required in a long run.
- Land use for settlement areas is to be reduced from the present rate of 130 hectares per day to a maximum of 30 hectares per day by 2020.

THE GERMAN ENVIRONMENT INDEX (DUX)

To be able to identify whether the environmental situation is developing in a direction corresponding to these aims, it is necessary to have indicators serving – in a manner comparable to the inflation rate or gross national product in the economic realm – as a yardstick for the condition of the environment in Germany.

To meet this need, an 'Environment Barometer' (Umweltbarometer) has been created which makes the development of the environment measurable by a few indicators. These indicators cover main issues of environmental protection and are connected to policy targets.

The six indicators of the Environment Barometer stand for the issue areas of climate, air, land use, water and resources (energy and raw materials). The German Environment Index (Deutscher Umweltindex, DUX) delivers a further aggregation of the information provided by the Environment Barometer, summarizing the results as a single number – an 'environment index'. The DUX connects indicator values with goals (distance-to-target concept). The Environment Barometer and the DUX are updated at regular intervals, and are complemented by information concerning the individual indicators (www.umweltbundesamt.de/dux/).

Sustainable development has to be achieved in real fields of action. Whether a system makes progress on the path to sustainability can - from the environmental viewpoint - only be judged if the development of the profile of environmental demands generated by that system is rendered comparable with the corresponding sustainability goals by means of environmental indicators.

Tab. 1: German Environment Index (DUX)

Subject	State February 2002	Maximum points
Climate	604	1000
Air	682	1000
Soil	-100	1000
Water	295	1000
Energy	239	1000
Raw Materials	82	1000
DUX	1802	6000

SCENARIOS FOR SUSTAINABLE CONSTRUCTION AND HOUSING

The profile of the environmental demands made by production and consumption arises from the analysis of the material and energy flows triggered by this system. In a research project focussing on sustainable construction and housing in Germany, national scenarios have been calculated for the development of construction and housing activities[1].

Using the methodology of 'needs-focused material flow analysis' (bedürfnisfeldbezogene Stoffstromanalyse) and the BASiS[2] material flow model, and involving key protagonists such as the housing industry, the academic community and public administrations, the project succeeded in identifying possibilities for setting development trajectories on track to achieve the essential environmental aims.
For this, various possible activities were identified to save resources in the area of construction and housing. In a specific'sustainability' scenario, the assumption was examined that the full potential of all available possibilities is exploited simultaneously.
The results of the computed scenarios demonstrated clearly that, for the area of construction and housing, it is indeed feasible to achieve the environmental aims of the national sustainability strategy, if efforts are successful to:

- upgrade the building and housing stock through refurbishment, modernization and joining of apartments,
- renew cities and towns vigorously,

- promote dense urban configurations and building designs,
- use available brownfield sites wherever possible,
- establish low-energy ("passive") house construction standard in the mass market,
- advance the thermal retrofitting of existing buildings forcefully,
- increase the share in space heat supply of biomass, cogeneration, and solar energy,
- use more recycled materials for concrete aggregates,
- use more renewable materials (wood), and
- realize cost savings through simpler constructions, using the savings thus achieved to improve energy standards, among other things.

The scenarios made clear which course is necessary from the environmental viewpoint for the 'construction and housing' action area. The requisite concrete and practical steps concern protagonists at various action levels, from the legislature through to building clients/developers, and planners.

The general sustainability indicators for the national level are not immediately applicable to the decisions of these protagonists: They must rather be reached on their own activity levels with specific and criteria and indicators that can guide their actions.
The 'information pyramid' (Fig. 1) provides a clear picture of these connections.

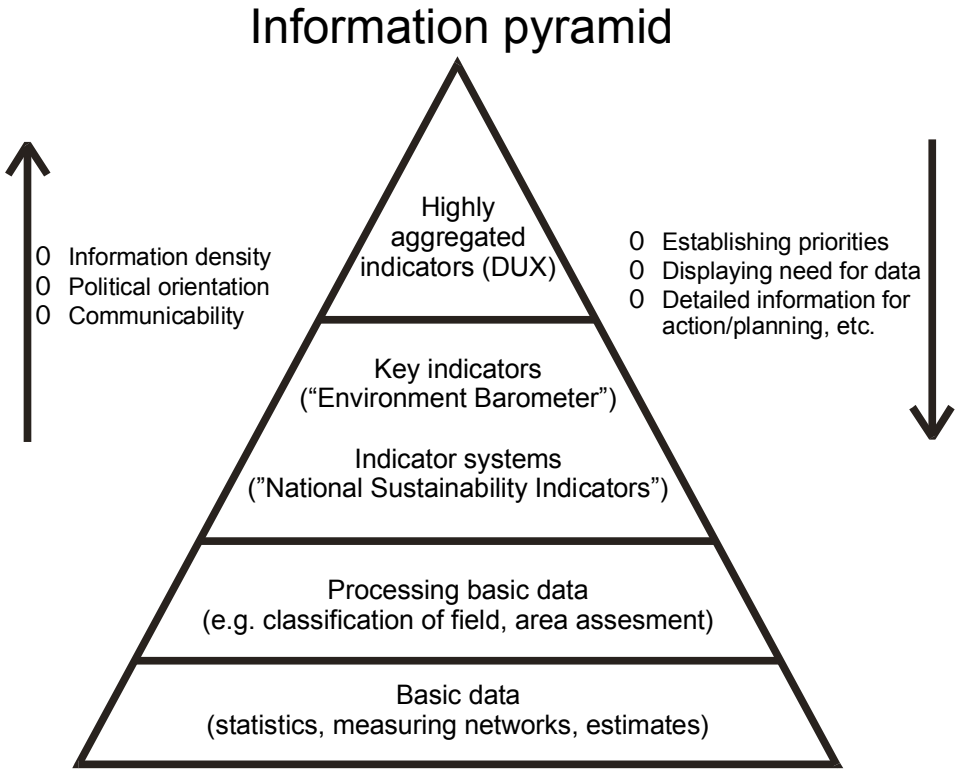

Fig. 1: The integration of data and indicators in the information pyramid of the DUX.

DEVELOPMENT OF ACTION–ACTOR-FOCUSED CRITERIA AND INDICATORS
A new project on 'criteria and indicators for environmentally sustainable construction and housing' is therefore seeking to close the gap described above, namely the absence of criteria and indicators which are capable of specifically guiding actions.

To adequately meet the requirements posed by the action- and actor-focused approach, it is essential to select criteria and indicators on the basis of both the variety of protagonists and the variety of guiding principles and aims which prevail in this complex and extensive area of action and needs.
To ensure sustainability, it is essential to harmonize economic and social requirements – which have one-sidedly dominated the housing and construction sector until now – with the concerns of environmental conservation. On the one hand the action possibilities have to be investigated at which this is possible and on the other hand the obstacles which stand contrary to this have to be removed. A comparison of the different social, economic and environmental guiding principles and aims in terms of agreement, neutrality or conflict reveals that the topic of land use for settlement areas is especially controversial[3].

Using a qualified selection of criteria and indicators, an important contribution can be made to a more rational discussion of conflict status and the possible approaches to resolving the various conflicts of goals. The operationalizability of the approaches and the representation of environmental impacts is to be guaranteed in the new project by means of indicators and EDP supported tools.
After some discussions it became clear that the indicators would need to impact upon existing decision-making operations of the various protagonists which shape the housing and construction area. This presented the challenge to identify the web of protagonists in its breadth and interlinkages, and to explore essential decision-making operations.
The following two sections present these aspects of the project: the structure of the selected indicator model and the actor network analysis.

STRUCTURE OF THE INDICATOR MODEL

The search for well-targeted indicators is at the centre of interest of the indicator concept demonstrating the environmental impact of the activities of construction and housing protagonists. This means that indicators should directly address protagonists and their possibilities of intervention. However, beyond this a universal coherence of indicators is also aimed at in order to be able to aggregate environmental impacts across the different levels.
Giving consideration to these requirements and the three dimensions (social, ecological, economic) of sustainable development, a multi-column and multi-layered indicator catalogue has been designed, which can be supplemented with further indicators when required.
The model contains two basic types of indicators: 1. actor indicators, 2. universal indicators (Fig. 2).
The actor indicators are tailored to different key protagonists of the various activity levels. Activity levels which need to be taken into account include: object (single building), neighbourhood, municipality, region, state.
The actor indicators will be suited for immediate assimilation into existing decision-making and operational processes and will make it possible to address target groups directly. Building and construction industry enterprises will be confronted with different indicators than housing associations or municipal planning departments.
The universal indicators will, in contrast, allow for permeability and aggregation along main environmental issues and across different activity levels. Wherever feasible, the actor indicators shall be chosen such that their translation into the universal indicators is possible. For example, per-capita carbon dioxide emissions is a suitable universal indicator.

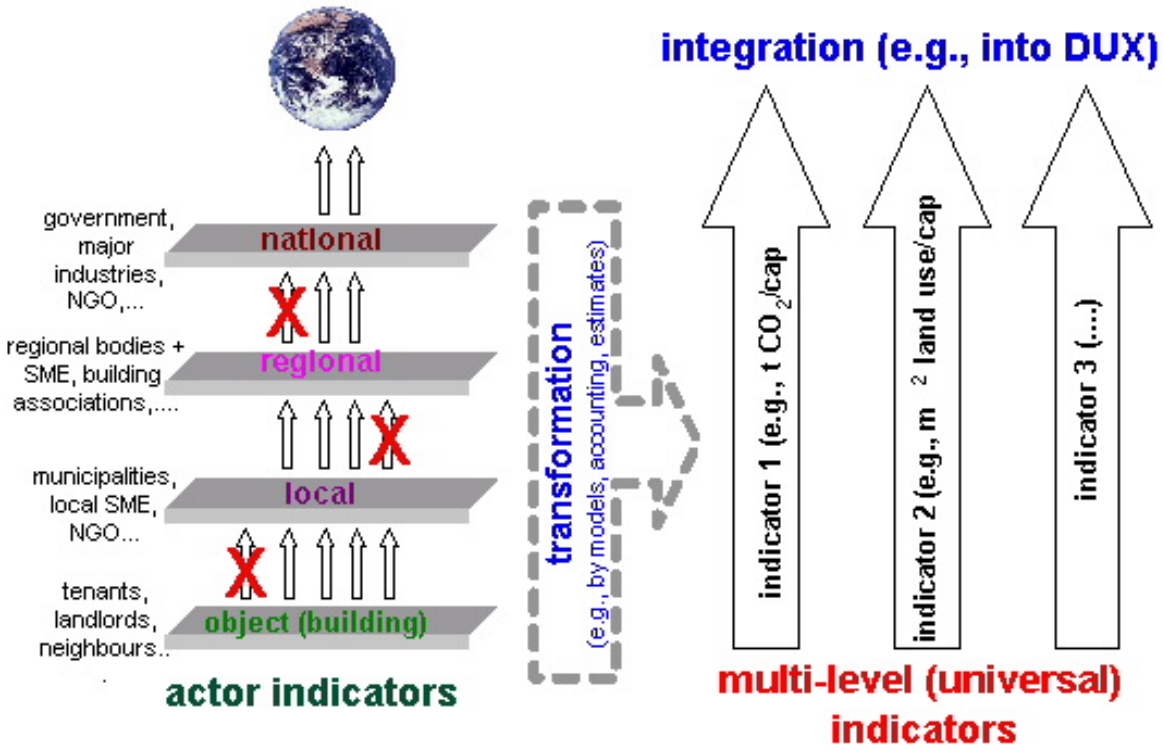

Fig. 2: The connection between actor indicators and universal indicators

This implies that indicators need to be sought for the different actor groups which can be converted into CO_2 emission equivalents or allow estimated values. The number of universal indicators is to be kept within bounds, not exceeding 3 to 5.
An analysis of available local, regional and national sustainability indicators found that environmentally oriented universal indicators are to be sought among the following: land use for settlements, solid wastes, CO_2 emissions, non-renewable primary energy consumption, drinking water consumption, share of renewable energy sources, waste recycling ratios.

ACTOR NETWORK ANALYSIS

For the housing sector, the construction industry, housing associations, clients/developers, crafts enterprises and architects as well as planners have been identified as essential protagonists. Examination of the life cycle of buildings demonstrates that not only is the actor network in fact much wider, but also a number of protagonists who have considerable capacity to exert influence must be given greater consideration. These include, e.g., credit institutions, insurance companies, and water and energy supply companies.

With regard to the influence of actor groups on energy and material flows, a distinction can be drawn between the demand side – investors, owners, users – and the supply side – building material manufacturers, building firms, utility suppliers, service providers. The demand side is concerned primarily with issues of sufficiency, the supply side with issues of efficiency.
As it can be assumed that the actor groups on the supply side already seek to maximize efficiency as a part of their business management considerations, the project focuses especially upon the demand side. Proceeding from the demand side, the project examines, step by step, those actors which influence this side through their supporting, advising, planning (et cetera) activities.

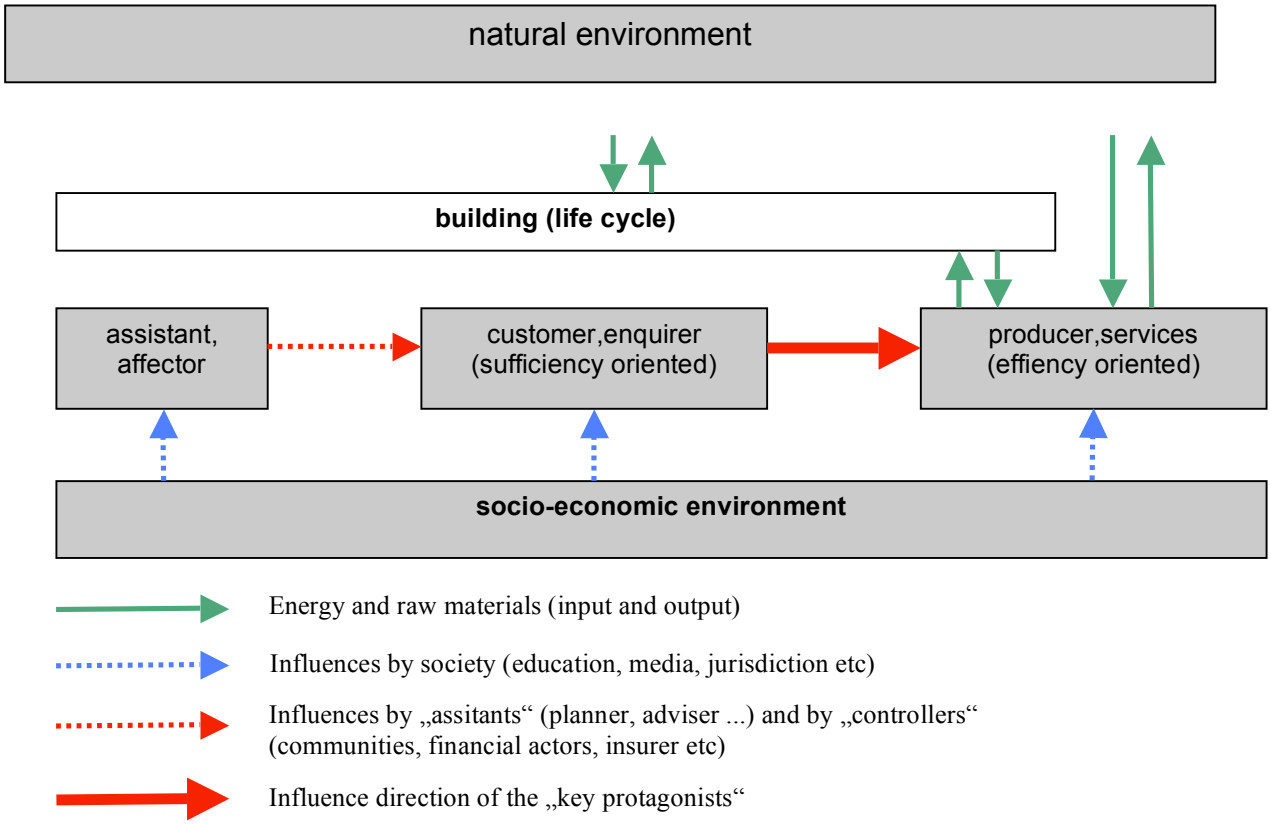

Fig. 3: Simplified network of examined actor groups

The owners of apartments and houses play a key role in influencing one-off (at the construction stage) and ongoing (in the building operation phase) energy and material flows. This group, however, is highly heterogeneous. Specific owner sub-groups pursue specific strategies with regard to their time horizon when formulating aims and considerations, their profit expectations, their tax status and treatment as well as their personal or institutional attitude concerning environmental and health issues.
These strategies have partly changed within recent years and will continue to change. Analysis of these strategies delivers the basis for linking them to indicators and tools for identifying and influencing environmentally relevant effects – work which will be done in the next steps of the project.

Notes

[1] „Stoffflussbezogene Bausteine für ein nationales Konzept der nachhaltigen Entwicklung – Verknüpfung des Bereichs Bauen und Wohnen mit dem komplementären Bereich öffentliche Infrastruktur“ (material flow related modules for a national concept of sustainable development – combination of the area of construction and housing with the complementary area of public infrastructure), research project on behalf of the German Federal Environmental Agency (UBA) carried out by Öko-Institut, and Institut für ökologische Raumentwicklung (IÖR) Dresden

[2] BASiS = **B**edarfsorientiertes Analysewerkzeug für **S**toffströme **i**n **S**zenarien (needs-oriented analysis tool for material flows in scenarios)

[3] Chmella-Emrich, E., Greiff, R., Steinmüller, B., Werner, P. u. Wullkopf, U. (1999): Beitrag der Wohnungspolitik für eine nachhaltige Entwicklung (contribution of housing policy to sustainable development). Hearing of experts on behalf of the German Ministry of Transport, Construction and Housing and the Federal Agency for Building and Spatial Planning, Institut Wohnen und Umwelt, Darmstadt (summary in English)

Assessment of building environmental performance for housing developments in Hong Kong

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ABSTRACT

Translation the guiding principles and aims of sustainable development strategies and plans into specific development is the real test of successfully implementing sustainable development. This paper focused on the building environmental issues of sustainability and used a housing development in Hong Kong as an example to demonstrate how the building environmental performance could be assessed and principles adopted at the planning stage.

At building design level, the building environment performance is determined by a number of performance indicators such as daylight, natural ventilation, solar heat gain and microclimate etc. A comprehensive assessment scheme was adopted to test different options on site planning and building design. It is found that the performances in these aspects are highly affected by the unique high-rise and high-density urban contest of Hong Kong. Effectiveness of design options is usually site-specific and subject to the local site constraints. Design optimisation has to consider proper site planning and built form to maximise the harnessing the natural resource.

1. INTRODUCTION

The HKSAR has a total land area amounting to just over 1,000 sq km. Only 9% of which is developed. Current growth projects envisage that the population of the HKSAR will increase to 8 millions by 2016. At the same time almost 950 hectares of existing development have been found to fail to meet reasonable standards of design and environmental quality. This presents an enormous challenge for the construction industry to properly address the environmental implications. These are unique challenges that are not typically replicated in other countries.

The prevailing density of development means that an overall quality improvement in the built environment cannot simply emerge at the level of individual building design. A recent study [1] has found out that the high-rise and high-density built environment of Hong Kong has resulted in certain extent of deficiency in the provisions of daylight and natural ventilation in the existing residential buildings. The current building regulations allows buildings to be built with small separation between buildings (Figure 1). Without appropriate guidelines for design, ineffective site planning and building designs are resulted, which not only reduces the potential for natural ventilation and daylight but also worsens other building environmental issues such as solar heat gain, microclimate, pollution dispersion etc. To facilitate the work of building design optimisation, appropriate tools and technique are required to assess these parameters. In this paper, an assessment scheme was proposed and used to optimise the design for a housing development in a typical built environment of Hong Kong.



Figure 1. Typical housing arrangements in Hong Kong

2. BUILDING ENVIRONMENTAL PERFORMANCE ASSESSMENT

The assessment framework, criteria and the related indicators for building environmental assessment have been established in many countries, including the BREEM developed by the UK Building Research Establishment, LEED by the US Green Building Councils and GBC 2000 etc. [2]. In Hong Kong, the HK-BEAM is adopted by many building designers or developers as one of the assessment tools for green building design [3]. The scope and scale covered by these assessment tools are different. Levels of inclusiveness may cover the product level, building level, building and supporting infrastructure level, community level, and building stock level. Due to the variations among different countries in the scarcity of resource, value of land, arability of technology etc, benchmarks and weighting are various in these systems to incorporate the elements of local context. In site planning and building design level, the elements of building environmental assessment may include the provisions of natural ventilation and daylight as well as controls of microclimate, pollution, solar heat gain and view etc. These parameters are highly affected by the master planning and building design of any development, which requires design optimisation at planning stage. Table 1 Summaries the weighting of these parameters in these assessment tools.

Table 1 Major Environmental Indicators for Building Design.

Environmental Indicator	**Weighting**		
	HK-BEAM	**BREEM***	**GB-TOOL****
Natural Ventilation	6	1	0.58
Daylight	3	1	0.5
Microclimate	2	1	0.75
Solar heat gain	2	1	0.2
View	-	-	0.3

* BREEM for new office design

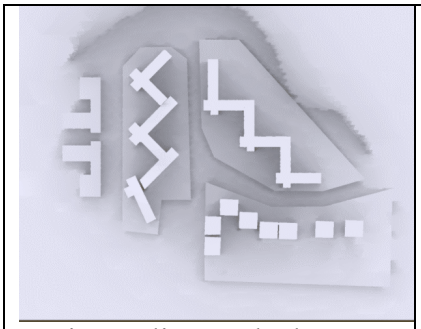
** Weighting out of unity. All performance criteria in GBC are set within performance scales ranging from –2 to +5.

While Table 1 addresses the framework for assessment, the assessment process, however, demands technical assessments and studies. To make the designer be able to compare the relative effectiveness of different design options, engineering study including the use of computational technique is necessary. A robust and concise scheme is required to determine the values of each indicator, which can be used to compare with the local benchmarks and determine the score of the design.

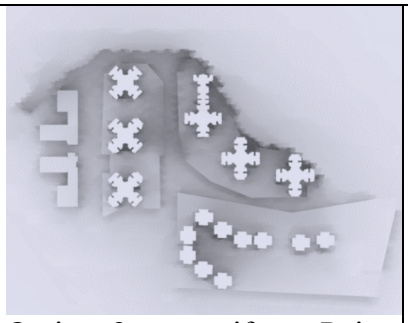
3 CASE STUDY

The proposed housing development will be built on a housing site in Hong Kong of about 30,000 m^2. Approximately, 6 nos. of 40-50 storey blocks will constructed with flat production of 4,400. On considering various planning and design constraints, the project team generated three design options which requires assessment on their relative performance on

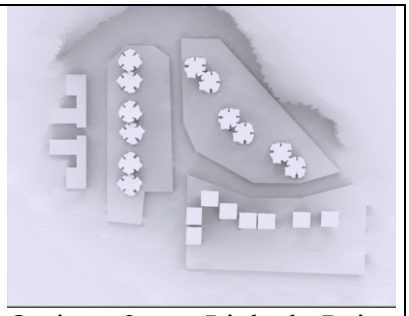
environmental aspects. Figure 2 shows the layout of these scheme options. Option 1 is a linear block design which owns the largest footprint. Option 2 is a typical cruciform design, buildings of which are widely found in Hong Kong. Option 3 is the linked point block which owns the smallest footprint among the options. It is envisaged that the performance will be different for these options on these indicators. Assessment on the overall performance is required to arrive the best option.



Option 1- linear Block



Option 2 – cruciform Point Block



Option 3 – Linked Point Block

Figure 2 Design Options of Case Study

4. ENVIRONMENTAL ASSESSMENT TECHNIQUE

The assessment of each indicator was conducted and credits was assigned, which is in 4 regions of ratings: “comfortable”, “fair”, “acceptable but required improvements” or “unacceptable”, similar to the approach adopted by other assessment tools. In general, performance indicators could be simply additive or weighted in according with their relative significance. The later was chosen for this exercise since a common scale for the assessment is insufficient to reflect the relative importance of each of the indicator. Based on HK-BEAM, relative importance in descending order is ventilation (6 credits), daylight (3 credits), solar heat gain (2 credits) and microclimate (2 credits). Using this order, the weight factors, normalised by their importance, were calculated for these indicators. View, though not an environmental performance indicator, is a vital factor in the unique high-rise and high-density urban context of Hong Kong. It, therefore, carried same weight as the overall environmental performance, i.e. of value of 1, in this study. The score were benchmarked against the best available value under the design conditions.

Throughout the design process, appropriate design strategies that would ease assess to wind, daylight, prevention of excessive solar gains and provision of good view have been identified. Proposed innovative design solutions, which may have great cost implication, were also addressed to justify their environmental performance.

4.1 Natural Ventilation

The function of ventilation should not be limited to health but cover the comfort and energy conservation as well. A well-ventilated room can enhance air circulation and therefore provide better thermal environment control that owns the potential to reduce energy consumption on air conditioning. The performance of ventilation has been assessed on its potential to achieve ventilation rate in terms of average air change rate. Ventilating coefficient in 3 regions of the building - the low level, the middle level and the high level were determined. The local effects due to the massing of the building blocks, their orientations and façade design e.g. provision wing-wall, have been considered. The issues on pollutant removal, lowering of internal temperature and provision of sufficient air-flow to improve thermal comfort were also assessed for these options. In this study, Computational

Fluid Dynamics (CFD) simulations have been demonstrated to be an effective technique that can assess the performance in this perspective.

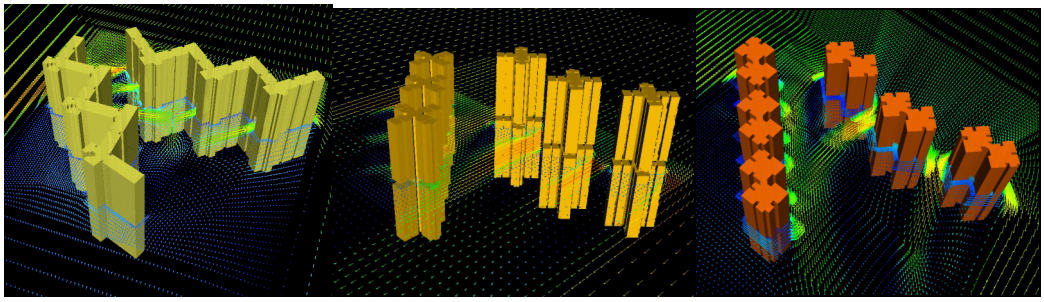


Figure 3 Wind flow diagram for different types of building forms

It is found that the influencing parameters that determine the ventilating potential are :

- Land Coverage
- Built Form
- Buildings Separation
- Building Heights
- Building Orientation
- Sky Windows

The study concluded that the ratio between the area of a site covered by buildings and the open ground area without buildings within the site affects the resistance that wind encounters in the particular site and results in the decrease in wind speed. Increasing the land coverage reduces the wind velocity around buildings and thus reduces their natural ventilating potential, both indoors and outdoors, in the open areas between buildings. Generally, the more spread out the buildings, the better the ventilating potential. On the other hand, the spread out of buildings would hinder wind penetration through buildings such that poor ventilating potential for buildings in the leeward side would be resulted. The height of buildings would affect the overall ventilating potential as well. Graduate increase in building height in the direction of prevailing wind can improve wind flow through the development so to improve pedestrian comfort. Each building creates an area of reduced wind velocity on its leeward side, therefore, the distance between buildings would be a crucial factor that determines the potential for natural ventilation. In the context of the high-rise built environment of Hong Kong, it is the width of the buildings, rather than their height, should be the governing parameter in specifying minimum distances between buildings.

4.2 Natural Lighting

For a residential development, it is necessary to ensure that sufficient daylight level can get inside an occupied space for psychological, health and safety reasons. The performance of daylight was assessed according to the amount of light received within a building at various floor levels. Detailed study of the overall extent of daylight performance can be carried out using computer simulation program such as *Desktop Radiance*, in which the terrain, latitude, altitude of the site, sky conditions as well as the time under analysis were all taken into consideration. For this kind of simulation, three-dimensional geometric models were used as input to generate spectral radiance values in the form of photo realistic images (Figure 4). Direct sunlight, sky luminance and contribution from the external surface reflection and internal surface reflection were all examined.

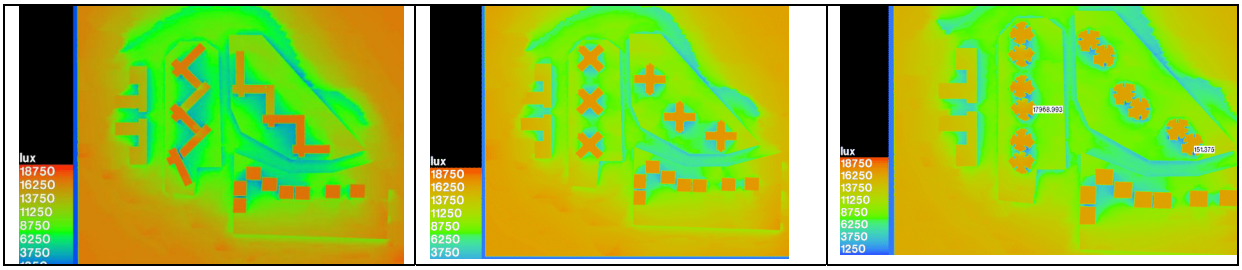


Figure 4 Daylight Simulation Results

On the design of natural lighting, it is found that its performance is usually beyond the issue of building design itself. Town planning constraints could determine the overall daylight performance of the site. For the given site, assess to daylight for any particular room is affected by horizontal obstruction, building separation and window glazed area. Results show that building arrangement and built form with less internal obstruction would result in better daylight. It is also found that the window glazed area could be an effective measure that can be used to compensate the deficiency of daylight due to poor site planning.

4.3 Solar Heat Gain

Solar heat gain is an important issue for sustainable housing design in Hong Kong as a significant amount of energy is used for air conditioning system during summer time. Solar heat gain to a building could be determined by the amount of the sunlight (direct and diffuse) reaching it. If the building is shadowed, heat gain due to direct solar radiation would be minimal, although diffuse solar radiation still contributes to the amount of solar heat gain. Thus, when calculating the total heat gain by solar radiation when the building is shaded, only diffuse solar radiation would be considered. Shadowing or a proper building orientation is effective measures to control the overall solar heat. Alternatively, reducing solar heat gain on building façade through proper shading design is also effective. An assessment on the optimisation of the shading designs in terms of their dimensions and orientations were required. Credits were awarded to options that can accommodate such shading design.

From the simulation results, it was found that the reduction of solar heat gain in building by the building blocks themselves were more effectively implemented by the height of the buildings, rather than the built form. In general, the more spread out of the buildings, the better would be their shadowing potential.

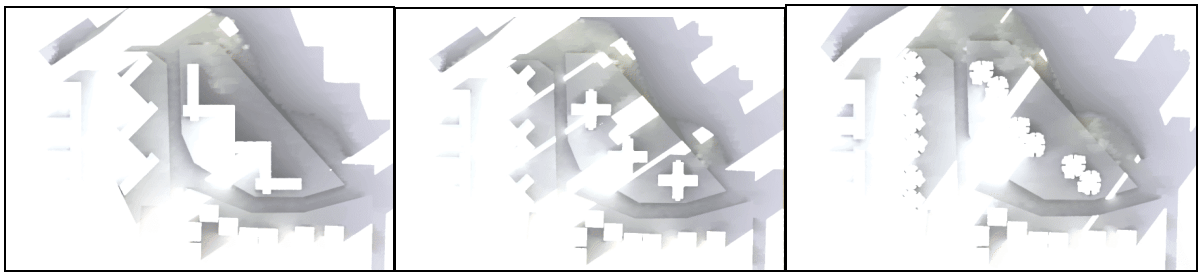
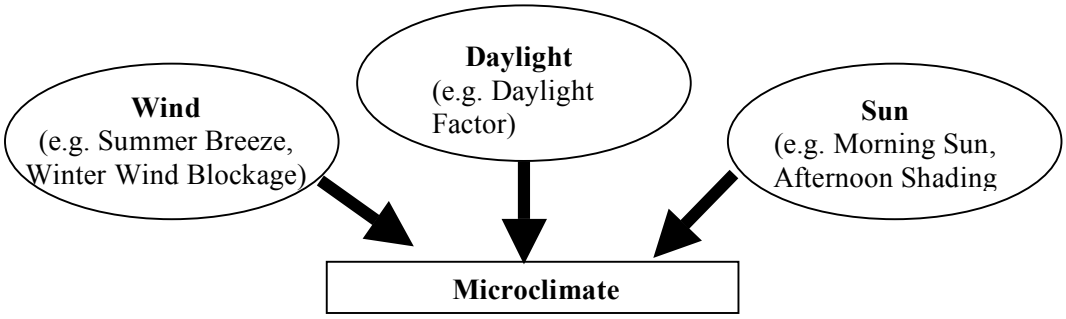


Figure 5 Shadowing Effect for the three types of building blocks in summer at 3 pm

4.4 Microclimate

Microclimate conditions achieved in the public areas such as the podium and skygarden affect the communal activities in these areas. Pedestrian comfort for various functions in the housing development is the main issue to be considered in this aspect. The above-mentioned three major components are also the key for a successful design of communal space.



The basic considerations in these aspects are that a mild wind condition could facilitate the social functions at common area during summer condition, while a strong wind effect in winter creates discomfort to the residents. Turbulence resulting from local wind climate and inappropriate building arrangement not only causes discomfort to the inhabitants but also the safety of the structure. Analysis using CFD can help to find out the relative performance of the options in these aspects. The study has established that special design feature such as urban windows help increase wind permeability among buildings, which reduce the coverage of stagnant zone in leeward side. Openings at low level would induce better ventilating effect for low zone, which normally form the worst scenario in most cases. However, due to implication in structural and construction process, incorporation of sky windows at middle level are commonly found.



Figure 6 Communal Skygarden

4.5 View

View assessment can be studied by determined the unobstructed angles, both vertical and horizontal components, viewing from a window. Quality of view, e.g. sea view, garden view or distant view, was not considered in the present investigation. The vertical and horizontal obstruction angles for the low zone were found to be critical to the options considered.

4.6 Overall performance

It is found that cruciform point block has best performance in ventilation, solar heat gain and microclimate, while the linked point block has the best daylight performance. If the score of these indicators are multiplied by their respective weight factors, cruciform point block possess the highest overall environmental performance.

Table 2 Summary for Overall Performance for All Options

	Ventilation	Daylight	Solar Heat Gain	Microclimate	**Weighted Environmental Score**	**View**	**Overall Performance**
Option 1 Linear Block	0.548	0.281	0.247	0.209	0.428	0.62	1.048
Option 2 Cruciform Point Block	0.625	0.257	0.256	0.303	0.48	0.74	1.22
Option 3 Linked Point Block	0.558	0.308	0.253	0.223	0.447	0.757	1.204

Alternative built form to enhance the building performance were also investigated. These enhanced options are linear block with skygarden, linear block with height variation, single point block with height variation, mixed cluster and mixed building block. It is found that the linear block with skygarden and height variation option can results in an environmental condition that is slightly better than the cruciform point block. The modifications, however, may have other implications, such as cost.

5. CONCLUSION

Effectiveness on planning and design of housing development requires the optimisation on the environmental performance in the areas of ventilation, daylight, solar heat gain, microclimate as well as other consideration such as view. Assessment scheme developed in the study helps designer to assess the environmental performance of the design options and arrive the most appropriate design in terms of building massing, orientation, height variation and façade treatment.

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Accepting the Challenge: Interpretation and Implementation of Sustainable Building in the Swedish and the Dutch Building Sectors

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1. INTRODUCTION

Sustainable building, e.g., a building practice that supports sustainable development, is currently used as an established concept without further deeper explanation. The origin of this paper is the conviction that the definition of sustainable building is far from just a matter of course. The perception is based on social discourse in which many actors, such as political bodies, the research community, the building sector, the media, etc. are involved. All of the above contribute to the discourse through formal and informal ways of communication.

In this paper, the current state of building practice that supports sustainable development in Sweden and the Netherlands will be presented through an interview with respondents in the building sector. Twenty-seven interviews were conducted in which architects, clients and environmental consultants expressed their personal opinions of: how far we have come today, supports and obstacles to further development and the respondents' interpretation of the concept "sustainable building". The aim of this study is to contribute to continued development of the definition and practice of "sustainable building".

2. METHOD

Interviews have been conduct with 27 actors, 14 in Sweden and 13 in the Netherlands. The respondents were selected according to their position of active influence on discourse on sustainable building in their country through building projects, through articles/books and/or statements in media. Four categories of actors were chosen: architects, environmental consultants, clients and architects also working as environmental consultants. The respondents were selected with the help from authorities within the field in both countries. The selection is strategic and qualitative in order to obtain the desired information (Falkheden, 1999).

Among the actors, three categories were identified (see Table 1). First, the pioneers who have been working with this issue since the 60s and 70s. They have been the driving force behind development and their work, as well as their personalities, is strongly identified with the issue. The second category consists of actors from a new generation with strong personal commitment, but with less experience. The third category consists of employees within an organization profiled as pro sustainable building. The latter group often has personal commitment but is not known to a wider audience as being spokespersons for sustainable building. In each country, only 7 of the interviewed work exclusively with sustainable building.

The interviews have been carried out as half-structured qualitative interviews with a supporting thematic guide (Kvale, 1997). Interviews in the Netherlands have been carried out in English. Three main themes covered by all interviews will be analysed in this paper: 1) What is your opinion of sustainable building at present? 2) How could we further support

sustainable development in building practice? 3) How would you define/characterise sustainable building?

Table 1: Respondents in Sweden and the Netherlands according to defined categories[1].

	Swedish interviews				Dutch interviews			
	Driving force Pioneer	"Less experience"	Employee	**TOTAL**	Driving force Pioneer	"Less experience"	Employee	**TOTAL**
Architect	3	1	0	**4**	5	4	0	**9**
Architect/environmental consultant	1	1	0	**2**	0	0	0	**0**
Environmental consultant	1	1	2	**4**	1	1	0	**2**
Client	0	1	2	**3**	0	2	1	**3**
TOTAL	**5**	**4**	**4**	**13**	**6**	**7**	**1**	**14**

The interviews have been transcribed word for word and decoded in order to answer the three questions posed above. Respondents have had the possibility to give reactions to the transcribed interviews and to the presented paper. What is presented in this paper is not the final results, as further analyses of the material is in progress (Femenias, in press).

3. SUSTAINABLE BUILDING PRACTICE AT PRESENT

In both countries, the main part of the respondents find that sustainable building is currently receiving less attention than 3-6 years ago. Mainly pioneers, architects and environmental consultants are disappointed with recent development. Two Swedish clients think that the issue is just as much in focus in practice but receives less attention in media. The three Dutch clients think that sustainable building is a natural part of Dutch building practice.

All respondents seem to find that the notion of sustainable building is generally spread in the building sector and that it has been implemented at a low level during the last decade. In the Netherlands, the National Package[2] is becoming known and used. In Sweden, for example, building product declarations are common and clients often ask for environmental and quality certification when engaging consultants. However, the development is found by most of the respondents to be too slow and the larger global issues are not addressed.. The main cause pointed out in the Netherlands is that the issue is not as high on the political agenda as it was 5 years ago. The political strategy of letting the market handle development is not enough. In Sweden, efforts seem to be more on "paper" than in practice. The larger clients, contractors and the building material industry are engaged but several respondents indicate a gap between the direction taken by the companies and the people working in the field. Two pioneers say that Sweden is behind in development and no longer a front-runner, for example, as pertains to energy issues. In both countries, the respondents express a lack of economic support for development projects.

4. SUPPORT FOR AND OBSTACLES TO SUSTAINABLE BUILDING

In the interviews, support and obstacles are represented on three levels: the social level, the building sector level and the building project level.

[1] All except two respondents (clients) have a formal education as architects which was not a deliberate criteria for choice.

[2] The National Sustainable Building Packages are voluntary measures for sustainable building introduced in 1996 and often used as an official measure or (minimum) standard for sustainable building (Femenías, 1999).

4.1 On a social level

In both countries, commitment on the political level is seen as one of the most important issues. Subsidies, amongst others for development projects, are seen as important and economic incentives/tax regulations as something that would stimulate development. In Sweden, it is seen as a major obstacle that government authorities do not respond to initiatives taken by the building sector by, for example, providing economic incentives for alternative sewage systems and providing disposal for sorted building waste. Some, 6 out of 14 of the Swedish respondents and 3 out of 13 Dutch respondents, mention that building regulations should be more severe. Others, like the Dutch respondents, think that regulations are already severe enough. The National Package is seen as supportive in the Netherlands.

In both countries, media is seen as important in setting sustainable building on the public agenda. However, as mass-media often focus on negative events it can also be a hindrance. In both countries, fanaticism is seen as an obstacle and step-wise development is preferable. Furthermore, low energy prices and low water prices are mentioned as obstacles.

4.2 On a building sector level

Good examples and demonstration projects are seen as an important support by the majority of the respondents. In addition, good architecture is seen as supportive, as well as well-reputed architects who are engaged in sustainable building projects. A special "sustainable building look" is seen as an obstacle by some Dutch actors. Architects who focus on aesthetics are seen as an obstacle in Sweden, and in both countries, a change in the education of architects towards more building physics, technique and sustainable building issues would be appreciated.

In both countries, actors mention that an economic recession can be a support for the development, but some Dutch actors find the current high pressure on the housing market as a support as the prices are already high and, consequently, extra investments are possible. In general, short term economy is seen as an obstacle and the focus on profit within the sector that augments the time pressure. A lifecycle cost perspective would be supportive.

In Sweden, conservatism, opposing forces, power structures and structural problems in the building sector are seen as major obstacles. Leading companies that engage in sustainable building issues are supportive, as well as individual commitment. Co-operation in the sector concerning information and, for example, putting pressure on the building material market is also seen as supportive. Among respondents in both countries, few use ISO certification within their organizations. There seems to be scepticism as to its efficiency and some use other systems. Small companies cannot use the certification due to the costs involved.

Swedish respondents reflect the lack of popular versions of research results and appropriate forums for the diffusion of these. Two architects expressed the lack of a consistent picture of the problem and "hard facts" as an obstacle to their engagement to sustainable building.

4.3 On a building project level

Engagement, demand and control from municipal authorities is seen as supportive in building projects in both countries. In Sweden, decision-supporting tools are seen as the most important support followed by an engaged client and the aid of an environmental expert/consultant in the process. Also in the Netherlands, decision-supporting tools and environmental experts are seen as important. In Sweden, some respondents mention the

disadvantage of being a small firm, as tools and experts are expensive aids. Complicated tools are seen as an obstacle. European co-operation is seen as supportive in diffusing knowledge. Interdisciplinary teamwork in the design process and participatory design are seen as indispensable by some respondents in Sweden as well as consolidation of the position of architects in building projects.

A major obstacle mentioned in the Swedish interviews (7 out of 14) is the lack of reliable information and data on building materials. In the Netherlands, the major obstacle mentioned in 9 out of 13 interviews is the cost of building. In Sweden, lack of knowledge among builders is mentioned and, in the Netherlands, the lack of knowledge among private clients. Economic, and other kinds of arguments, other than environmental ones are seen as supportive in the decision-making process in both countries. It is seen as supportive in Sweden that the developer is also the owner/administrator of the property.

5. INTERPRETING THE CONCEPT SUSTAINABLE BUILDING

The interviews give personal interpretations, and of all the respondents only two environmental consultants in the Netherlands have a definition in the organisation to fall back on. This is also because most of the firms in the study are small. Several respondents in both countries find it difficult to define the characteristics of sustainable building.

5.1 Official guidelines in Sweden

There is no official definition of sustainable building in Sweden. Guidelines for the built environment are found in one of the 15 national objectives for environmental quality (Comm. 1999/2000:13). The objective "A good built environment" sets focus on: energy efficiency, improved indoor climate, resource management, improvement of organizational capacity and knowledge capacity in the building sector (Boverket, 1999).

In the first national Swedish strategy for sustainable development from 1997, environmental dimensions were emphasized and the official term "ecological sustainability" was used. Governmental actions over the last years have increasingly encompassed financial, social, employment, educational and cultural measures (Ministry of Environment, 2001).

5.2 Interpretation of Swedish respondents

The term "hållbart byggande" is, in Sweden, gaining ground as the official translation of 'sustainable building'. However, the term "hållbar" is already used in other discourses giving it a different meaning and "hållbart byggande" can refer to buildings that are constructionally sustainable. This has resulted in the use of more easily comprehensive terms like environmentally "adjusted" or ecological building.

Among most Swedish respondents, the term 'sustainable building' is sometimes used. Two respondents find the term 'sustainable building' pretentious and one rejects the term 'sustainable building' altogether and wants to call it building practice that supports sustainable development. One respondent prefers the term "smart" building. All respondents, except one, reject the term 'ecological building'. 'Sustainable building' is seen as comprising more than just environmental issues. As one pioneer says, *" Environmental adjustment is a necessary condition but not a sufficient condition to obtain sustainable society."* 'Environmental adjustment' is seen as a technical issue. However, three respondents think that sustainable and environmental building are the same. A majority of the Swedish respondents do not see any meaning in a distinction between sustainable building and non-sustainable building except for demonstration projects. Others find it important to make a

distinction in order to keep the subject on the agenda. If there is no distinction everything can be called 'sustainable building'.

The interpretation of 'sustainable building' can be divided into six categories: 1) Three of the pioneers advocate a local perspective with smaller units, local democracy, small scale technical solutions. Focus is on the social dimension in which a running dialogue between people can influence the technical dimension. 2) Two respondents express a holistic view including the social dimension emphasizing resource efficiency, healthy indoor climate and local systems. 3) Two other respondents express what could be called an "architectural view" of the problem[3]. Focus is on comfortable buildings with high aesthetic and technical quality that will last. 4) Three respondents have their main interest in technical solutions in which energy efficiency is one important issue. 5) One architect has an urban perspective and finds questions regarding effective land use the most important. 6) The three clients express an approach which focuses on large-scale problems in the building sector. They seek solutions that are possible to fit in with already existing structures in society and that are possible to generalize.

Two respondents see tension between architectural quality and sustainable building. One of them thinks that sustainable building found all over the world proves that it is difficult to focus on both issues at the same time. One Swedish respondent expresses tension between sustainable building as sealed houses and a healthy indoor climate.

5.3 Official guidelines in the Netherlands

Sustainable building, in the Netherlands, is known as "Duurzaam Bouwen". In the National Environment Policy Plan-Plus from 1990, the concept was defined as "aiming to reduce the impact on health and the environment of construction, buildings and the built environment" (Hal, van et. al. 2000). A Plan of Action for sustainable building published in 1995 defines the concept as "consideration is given to environmental quality as a matter of course at every stage of the building process, i.e., from design to management" (VROM, 1995). Although these definitions for sustainable building focus on the environmental aspect, they are said to be based on the Dutch definition of sustainable development which refers to the Bruntland Report (WCDE, 1987) emphasis on a long-term perspective and equal distribution of resources.

5.4 Interpretation of Dutch respondents

Ten of the 13 Dutch respondents use or prefer the term 'sustainable building' as this is the official term used by the Dutch Government. Two respondents prefer the term 'smart architecture' and one calls his work healthy building. 'Environmental building' is seen as a part of sustainable building. Like in the Swedish case, some want to make a distinction between sustainable and non-sustainable building, while others prefer not to.

Among the Dutch respondents, the focus is more on building-related issues than on social changes. Two of the environmental consultants give a picture of sustainable building as including; 1) environmental issues, such as energy, water and waste reduction, and 2) other qualities, such as architectural quality, indoor climate, long lifetime, etc. This model can be

[3] Dalman has in an interview study with architects involved in the Swedish sustainable building expo Bo01 discerned their interpretation of sustainable architecture. She found that emphasis was on long lifetime, resource efficiency and good quality architecture and that this concept was found by the architect not to be different from the normal way of conceiving good architecture (Dalman, 2001).

used to categorise nine of the Dutch respondents. Five respondents focussed more on the "architectural view" (1). One respondent focuses on the environmental issues and three give equal priority to the two themes (1-2). For the remaining four respondents, one pioneer expresses a holistic approach, "human building" with a focus on indoor climate, renewable materials, participatory design, etc. Two respondents prefer an approach which sets technical systems in focus and one pioneer presents a ready model for sustainable building including environmental, process, and architectural qualities, as well as economic issues.

Tension between sustainable building and health and living comfort is found in five interviews. Sustainable building is seen as equivalent to energy efficient and sealed buildings, which is said to be in conflict with a healthy indoor climate. Furthermore, on respondent, a client, expresses tension between sustainable building and quality, where wood for facades, which is seen as part of the "sustainable concept", is proven not to be sustainable over time.

6. REFLECTIONS AND TENTATIVE CONCLUSIONS

The notion of sustainable building is on its way to becoming integrated in the mind and practice of actors in the building sector in Sweden and the Netherlands. However, it is still on a low level and this study points out the necessity of further developed definitions of sustainable building, as well as further support for continued implementation in practice.

The characteristics of sustainable building given by the respondents are based on individual interpretation. A variety of images are presented and, so far, no common categorization of definitions between the two countries has been found even if many ideas coincide. Official guidelines in both countries seem to focus on environmental issues but most respondents find that environmental issues are just one of several dimensions of sustainable building. The Swedish interviews reflect a slight confusion of ideas and present a range of approaches to sustainable building from locally based to generally applicable solutions and with commitment on a social level. The Dutch interviews reflect a more unified image in which official guidelines seem to be more present. About half of the Dutch respondents find other qualities, such as long lifetime and architectural quality more important than merely environmental issues. Social issues are less reflected in the Dutch interviews and, instead, building issues are addressed. In the Netherlands, there are indications that an already established idea of sustainable building can come into conflict with personal ideals of sustainable building, such as health and comfort.

7. ACKNOWLEDGEMENTS

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Total Quality (TQ) Assessment as the Basis for Building Certification in Austria

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1. INTRODUCTION

Building assessment and building certification are potentially stimulating the construction of user friendly, environmentally friendly, and cost efficient buildings. However, the concept will work only if there is customers' demand for this type of high quality building and if building owners recognise this market.

In Austria, the TQ Information Package has been developed since 1998 in order to stimulate the construction of user friendly, environmentally friendly, and cost efficient buildings.
The main parts of the TQ Information Package are:

- a computer based assessment framework with an automatic assessment procedure done by the programme, delivering the assessment result after all required data have been entered;
- a guideline how to achieve the best score.

It is the aim of TQ to provide the information necessary for designing a high performance building and to confirm the result by assessing the building in two steps:

- prior to construction and
- prior to handing over.

The TQ system does not assess architectural quality, but technical parameters that have to be taken into account during the process of designing the building. At the beginning of the design process, the design team and the client define the design targets for the building by means of criteria for the assessment framework and the scores they want to achieve; after assessment, a group of independent experts certifies that all the information used for assessment is correct.

Result of the TQ assessment is confirmed information about the building, the assessment result and the certificate.

Figure 1 describes the concept TQ is based on.

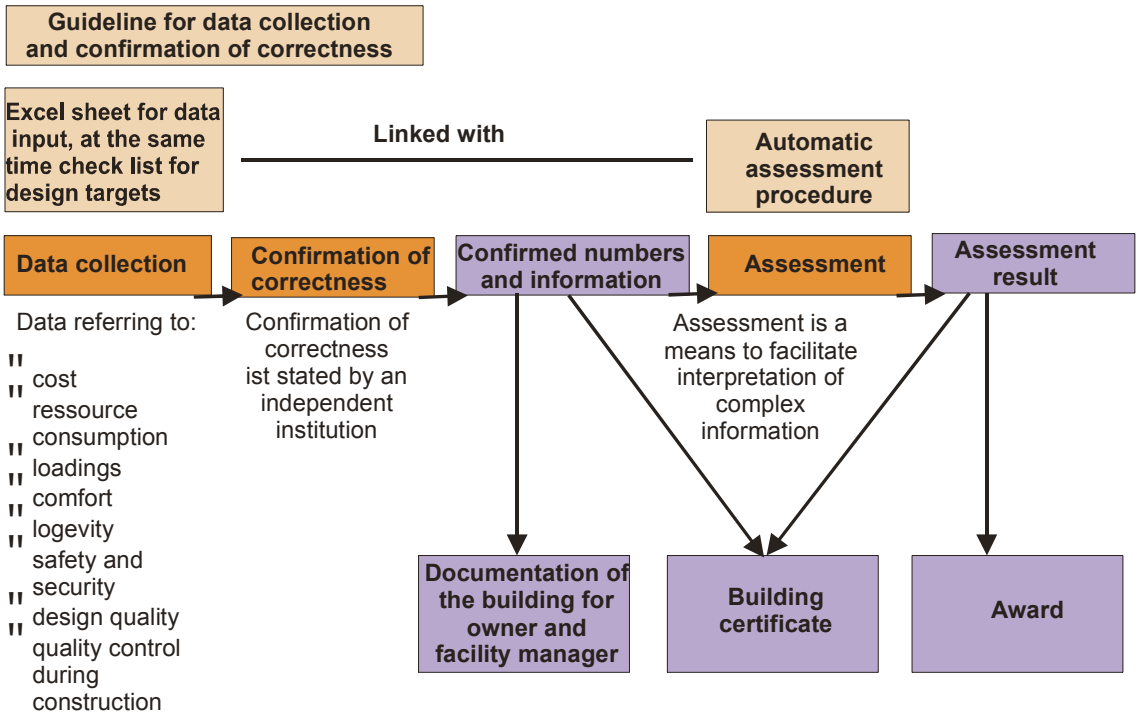

Figure 1 Concept of TQ assessment and certification

2. WHY DID WE END UP WITH THIS CONCEPT OF PLANNING, ASSESSING AND CERTIFYING IN AUSTRIA?

The concept of building assessment and building certification will contribute to stimulating the construction of high quality buildings only if it is practically used. Therefor, the TQ assessment system has been developed in co-operation with construction companies, building owners, architects and engineers. Documentation of this process is available at www.e3building.net.

These are their demands:
(1) low effort for data collection,
(2) transparency,
(3) easy assessment and time saving assessment,
(4) use of the assessment result as a marketing instrument.

According to their requirements,
(1) the assessment system is adapted to the design conditions in Austria; in order to decrease effort for data collection, the assessment is based on data derived from the planning process and quality control measurements necessary during construction.
(2) the assessment system is a programmed excel file (see figure 2) based on data input which remains visible in one column ("information column": green / grey boxes); next to the pure information being assessed, the assessment results appear ("assessment column": yellow / grey boxes); in some cases defined criteria might not be applicable, and they are marked by grey boxes in the "assessment column"; at present, some criteria are not assessed, because there is not enough experience with assessment scales yet. Due to user friendliness assessments scales are not visible in the computer tool, but they are available for everybody in the TQ guideline.

(3) the assessment system contains many automatic calculation procedures that support the user and save time: grey boxes in the “information column” contain information derived from automatic calculation from “support sheets”, such as the calculation of primary energy consumption of material use or CO_2-emission from heating energy consumption.
(4) data filed for assessment have to be confirmed by calculations, drawings, etc., and the assessment procedure is automatically done by the programme, in order to achieve comparable results and allow independent experts to examine the TQ file and issue a TQ certificate.

3. HOW DOES THE TQ CONCEPT WORK?

The following Figures should convey an idea of how the TQ concept works:

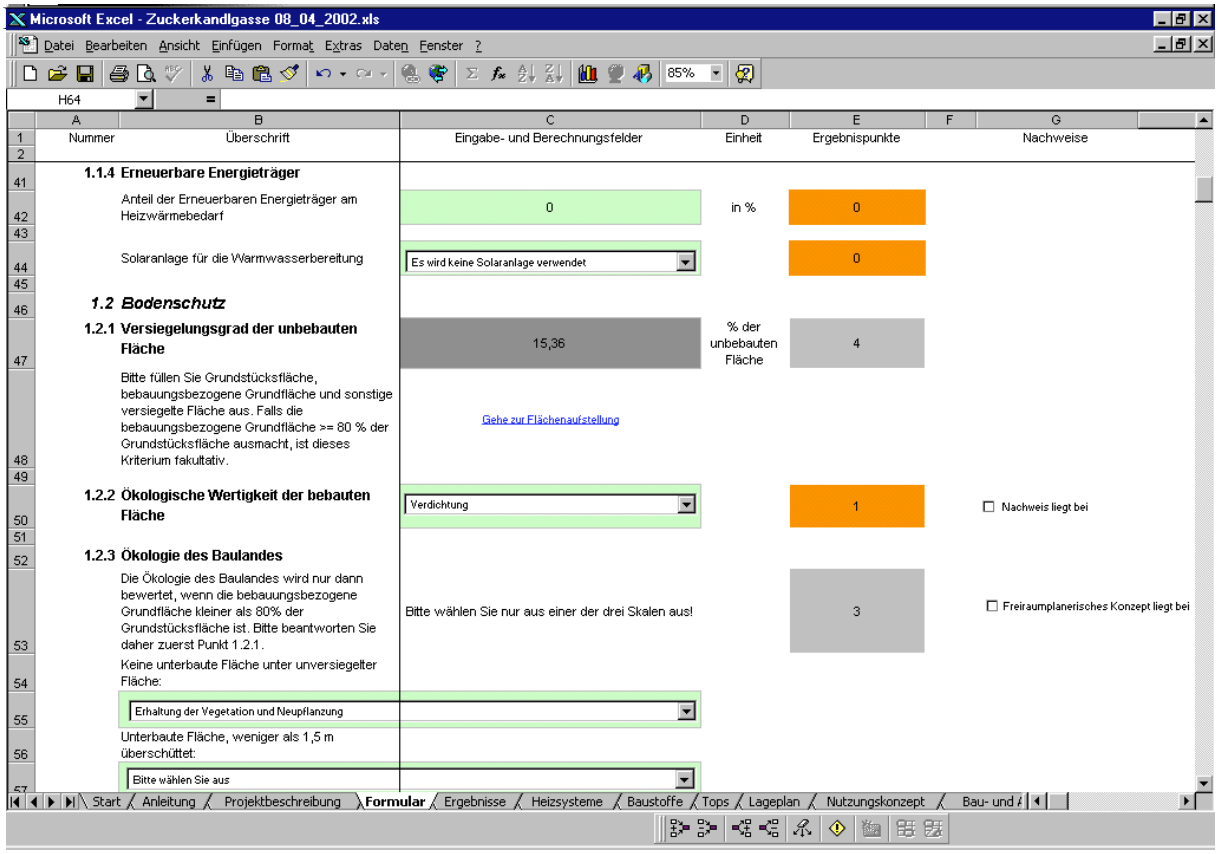

Figure 3 shows the “support sheet” of heating energy systems: as soon as you activate your heating system, the amount of associated primary energy consumption and CO_2-equivalent per kWh is linked with the heating energy consumption you filled in the "main sheet" and is automatically fed into the relevant box in the “main sheet”. Of course the pool of heating systems in the "support sheet" is limited and even if you identify your heating system in the "support sheet" you might find that your system produces less emissions that the system in the pool. In this case, you enter your own system or choose one system of the pool, but enter your emission data in the blue fields. As soon as you enter data in the blue fields, the default data will be inactivated. However, if you enter own data you will have to confirm them by means of a life cycle assessment, in order to guarantee comparability of results.

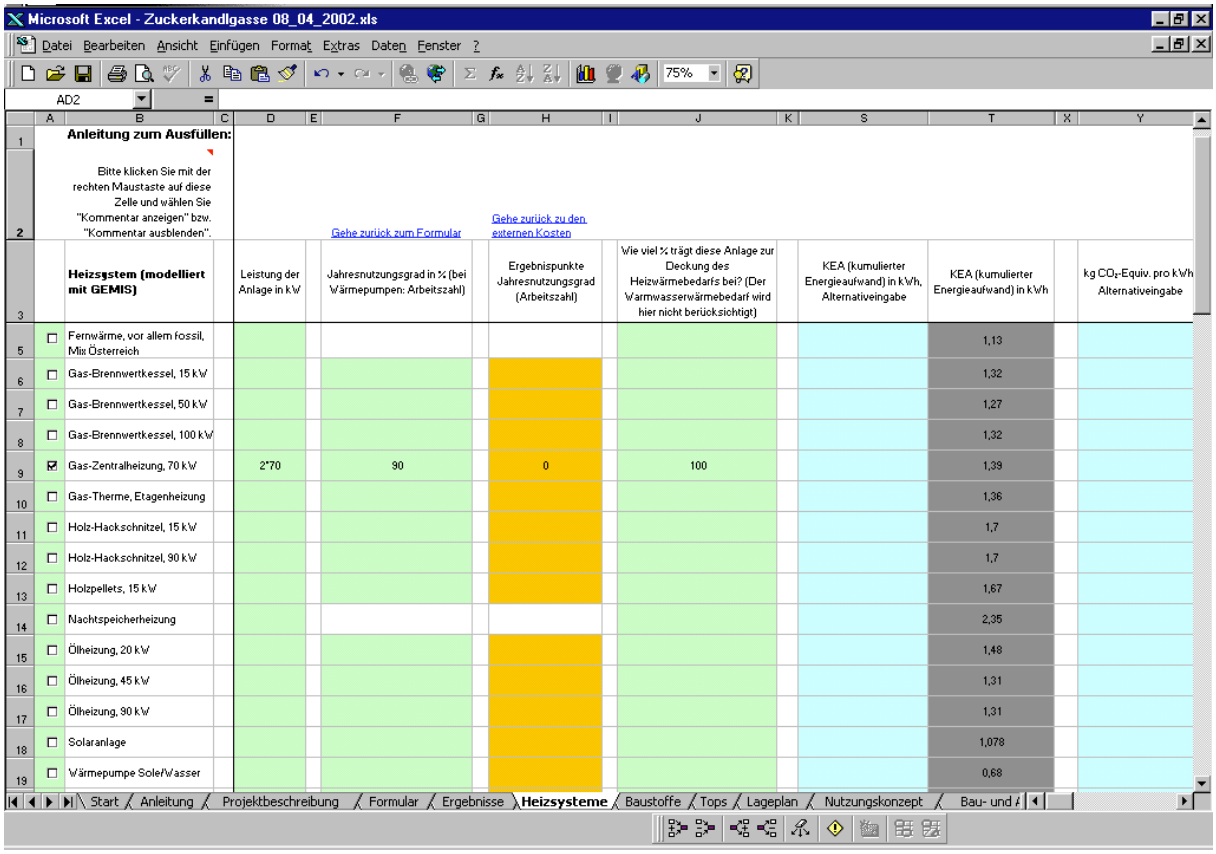

Figure 3 "Support sheet" of heating energy systems (pool of heating systems: column B; default primary energy consumption: column T; column S: if you want to use your own input data; column D–J: specific information regarding heating system)

Figure 4 shows the "support sheet" of materials. As soon as you enter the mass of a specific material used, default life cycle assessment data are activated and automatically fed into the relevant box in the "main sheet" (criterion "Primary energy consumption of building materials per m^2 and year"; criterion "CO_2-Equivalents from material use per m^2 and year"). You might find that your product produces less emissions than the material in the pool does. In this case, you enter your own emission data in the blue fields. As soon as you enter data in the blue fields, the default data will be inactivated. However, if you enter your own data you will have to confirm them by means of a life cycle assessment, in order to guarantee comparability of results.

The "support sheet" of materials also considers the issue of material transportation. Life cycle assessment data only contain emissions that are caused until the production process is finished. Then transportation to end user starts which is not covered in life cycle assessment data. For this reason, in this "support sheet" you enter transportation distance and transportation means. The CO_2-equivalents associated with the transportation means you selected will appear in the "main sheet" under the criterion "CO_2-Equivalents per m^2 and year from material transportation".

Figure 5 shows the assessment result, which is the list of TQ criteria, the scores achieved and the weighting factors used for aggregation.

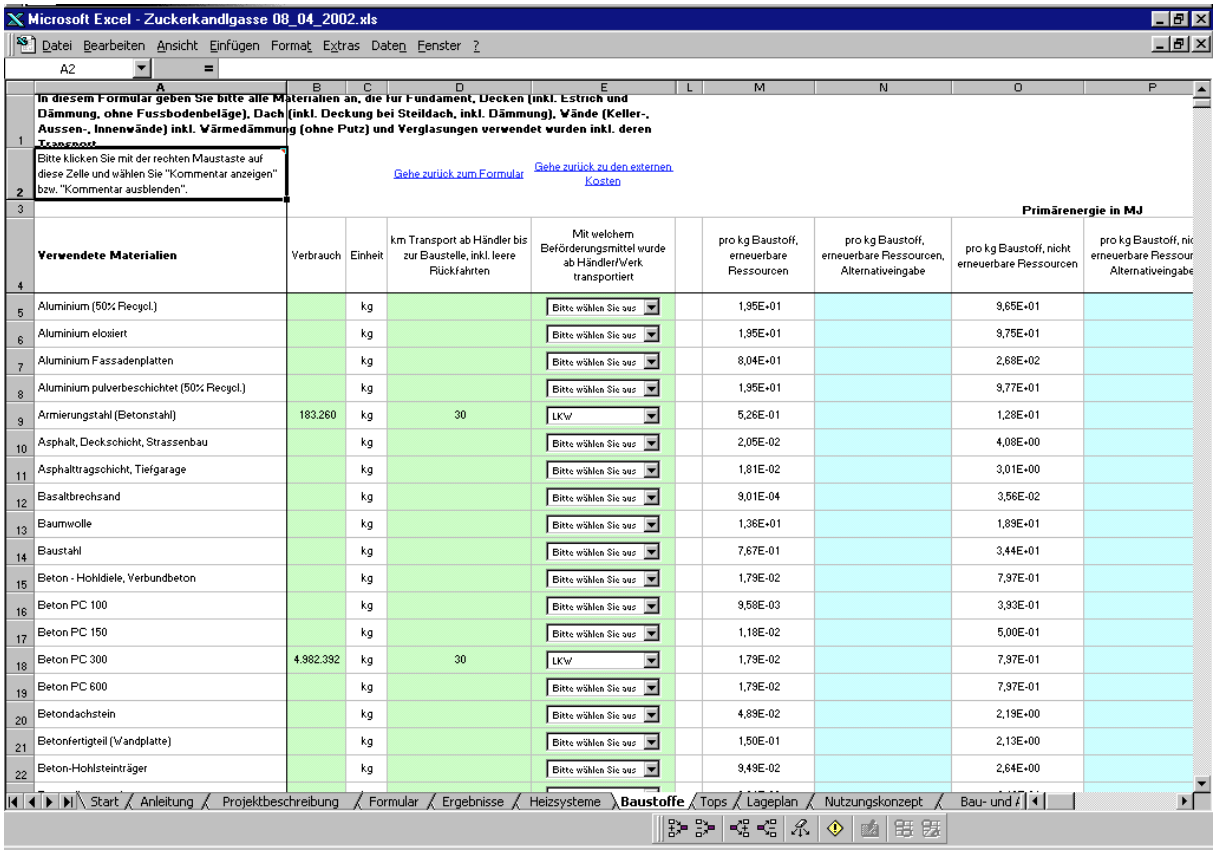

Figure 4 "Support sheet" of materials (column A: materials; column B: amount; column D: transportation distance; column E: which transportation means; two types of lorries, railway, ship)

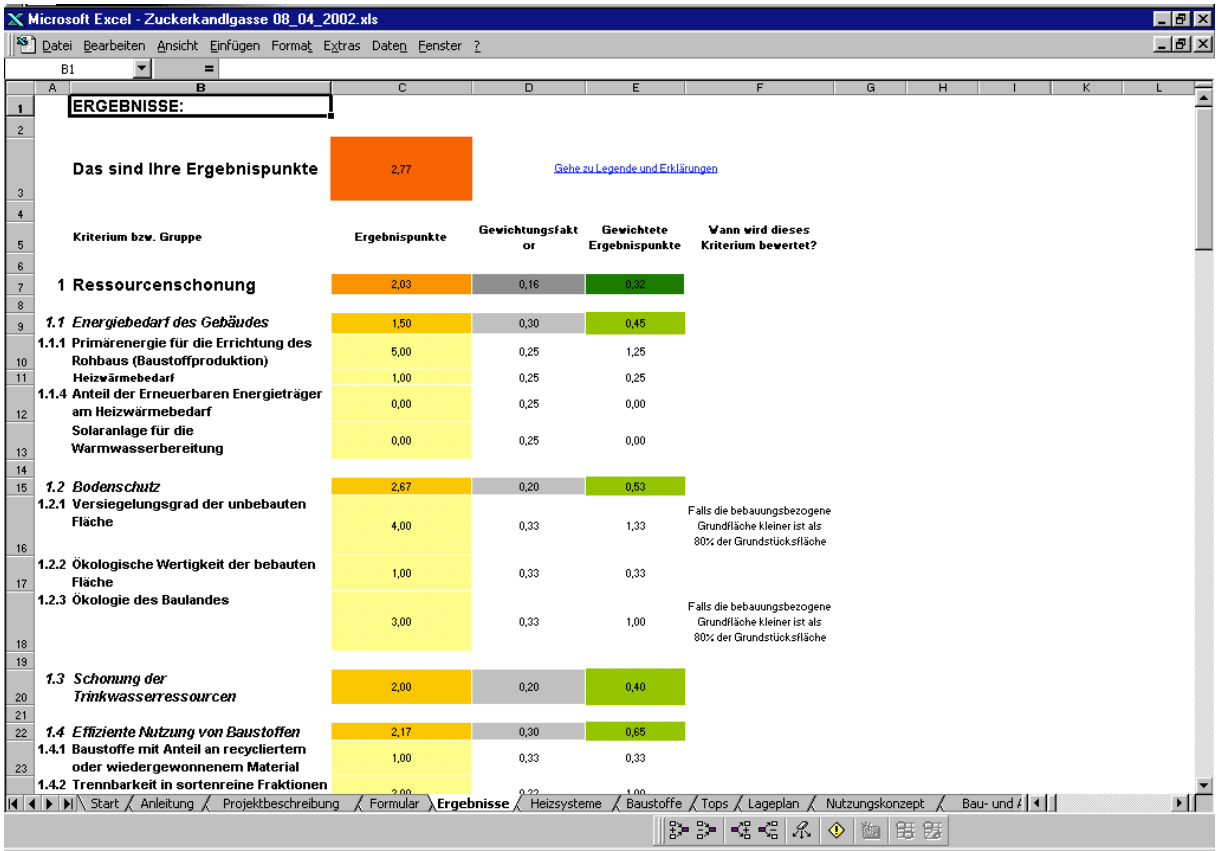

Figure 5 Assessment result - list of TQ criteria, scores achieved, weighting factors

4. TQ CERTIFICATE

The examined assessment file is the basis for issuing the building certificate. The certificate consists of briefcase responding all relevant information in short form with an approximately 30 page computer printout attached containing detailed information.
The briefcase consists of the following pages:
1st page: Photo of the project and certification acknowledgement
2nd page: Objectives of the evaluation program and presentation of the TQ working group
3rd page: Summary project description and issue level results of the evaluation:

- Resource Consumption
- Environmental Loadings
- Indoor Environmental Quality
- Durability
- Safety and Security
- Quality of the design process
- Quality of the construction process
- Quality of amenities and site
- Total average gained

4th page: Selected results with special meaning for the inhabitants (According to the results of an tenant inquiry carried out as part of the TQ project).
In Spring 2002 the first certificates for pilot projects are awarded.

5. WHO AWARDS THE CERTIFICATE?

The certificate is awarded by Arge TQ who consists of Österreichisches Ökologie-Institut, Kanzlei Dr. Bruck, Donau-Universität Krems and Institut für Baubiologie und –ökologie. It will be the responsibility of Arge TQ not only to examine the TQ assessment files and award the certificates but also to maintain and further develop the TQ assessment tool and the TQ guideline. At present, 12 pilot projects are under assessment. Building owners have realised the potential of a quality certificate for buildings as an advantage in marketing.

6. THE EUROPEAN PERSPECTIVE

For the construction industry, the German speaking countries form a common market. TQ assessment is not only applied in Austria but also spreads to Switzerland and Germany. In the pool of 12 pilot projects under assessment there are also two Swiss projects and one German project. One Swiss project that was constructed by Swiss Re (Swiss Reinsurance Company) achieves an excellent TQ assessment result: The office building Tuefi in Adliswil nearby Zurich (total heated area: 31,800 m²) was completed in 1998 and consists of one three-stories part and two five-stories parts. Below ground level an archive and a basement garage are situated (each of them two-stories). The offices are equipped with thermo-active concrete ceilings serving as heating as well as cooling elements. Due to the combination of massive (concrete) elements and a highly transparent building envelope the total building mass is medium (385 kg/m²). A photovoltaic system with a peak power of 22 kWp contributes to the production of “green electricity”. Heating energy and electricity consumption as well as environmental impacts are very low. The building provides outstanding working conditions and the proximity to public transport and other services.

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Low-energy Building Design as a Case of Multilevel Optimisation

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Analysis of energy use in all life cycle of a building (designing, realisation, using, modernisation, demolition and utilisation) is presented in the paper. General formulate of optimisation problem is described in the article. Minimalization of energy consumption is taken into account as the main criterion. Analysis of set of limitations determined by environment's problems and exploitation's problem is also presented in the paper. The problem is formulated in the category of system's theory. Multilevel and multioptimisation methods are used in the solutions of the problem.

1. INTRODUCTION

Necessity to reduce waste of energy, also in building trade, is evident and important part in strategy of balanced development. Connections between criterion of minimisation of waste of energy with criterions of balanced development are illustrated on Fig. 1. [1,7]

Method of estimation of waste of energy in all building cycle is presented in the paper. Whole cycle has been divided into basic units (Fig. 2):

- initial phase - decision about investing and establishing basic assumptions;
- phase of realisation - project and realisation of a building;
- phase of exploitation;
- phase modernisation - estimation, decisions, projecting and realisation (alternatively);
- phase of liquidation: demolition, utilization, and reclamation of the land.

Method of formulating and solving the problem is illustrated on Fig. 3.

Level 1:

Decision making process ($\boldsymbol{P_D}$), lasting whole cycle, while considering all activities which have influence on energy waste, is analysed. For the analyse system $\mathbf{S_0}$ (Fig. 3a) is used to estimate relations between decisions undertaken in each part of system.

Level 2:

System of building projecting (**DBS**) is simulated. Taken into account are:

- criterions and relations with other parts of building cycle presented on level 1,
- relations between building and environment.

Projecting process (***DP***) which is realised in this system settles minimisation of energy wastes in whole building cycle.

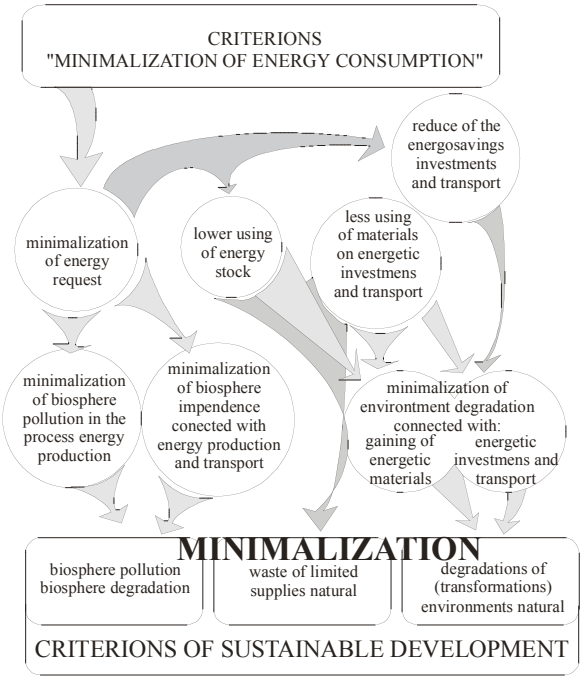


Fig.1: Relations between criterions of energy waste minimisation and basic criterions of Sustainable development.

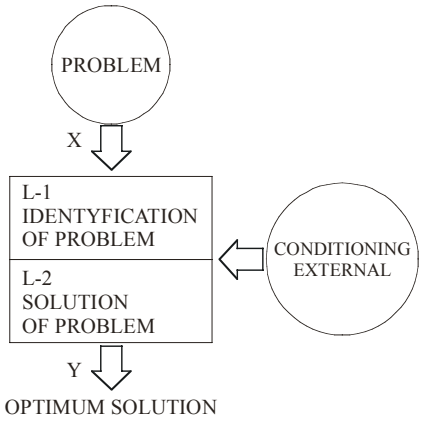


Fig. 2: General model of formulation and solving problem.

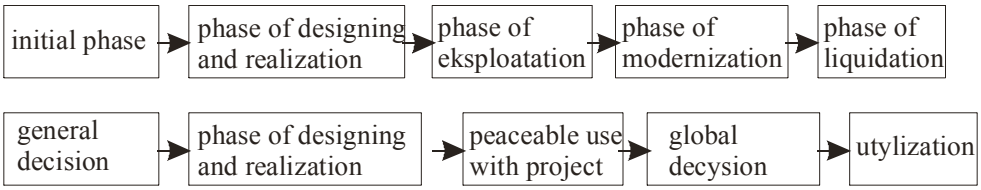
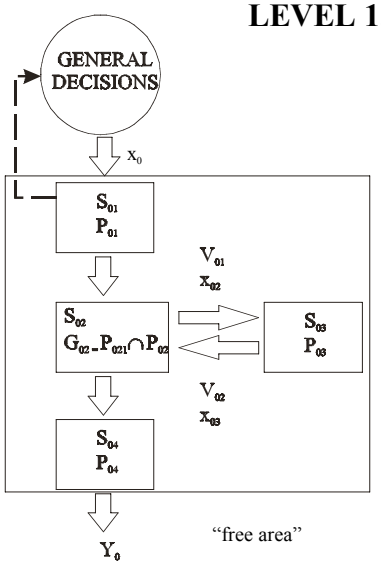


Figure. 3. Phases of building cycle.

LEVEL 1. SYSTEM OF TAKING DECISION S_0.



System $\mathbf{S_0}$ is defined as follows:

$$\langle x,m\rangle \in \mathbf{S_0} \Leftrightarrow \boldsymbol{P_D}(x,m) \in \mathbf{M} \wedge \exists\, m^* \in \mathbf{M} \quad (1)$$

given by:

$$\mathbf{K}[x,m;\ \boldsymbol{P_D}(x,m^*)] = \min \mathbf{K}[x,m;\ \boldsymbol{P_D}(x,m)]$$

with: <x,m> - couple,

$x \in \mathbf{X}$ - entry set,

$y \in \mathbf{Y}$ - exit set,

$m \in \mathbf{M}$ - set of variables,

$\boldsymbol{P_D} : \mathbf{X} \times \mathbf{M} \Rightarrow \mathbf{Y}$ function of process,

$\boldsymbol{K}$: $\mathbf{M} \times \mathbf{Y} \Rightarrow \mathbf{V}$ object function,

V - object of valuation.

Figure 4. Structure of $\mathbf{S_0}$ system: $\mathbf{P_{01}}$ **:** analysis and estimation of the relation $\mathbf{P(x_i,x_i)}$ between $\mathbf{x_0 \in X_0}$, $\mathbf{P_{02}}$ designing**,** $\mathbf{P_{02}}$ **:** realization**,** $\mathbf{P_{03}}$ **:** modernization $\mathbf{P_{04}}$ **:** distribution, utylization.

In set of object estimating criterions K, as basic are considered criterions:

K_E - minimum of waste of energy,
K_I - minimum of environment degradation, (2)
K_K - minimum of costs.

Process $\boldsymbol{P_D}$ is sequence of events. System can be decomposited into embracing phases of cycle subsystems $\mathbf{S_{0i}}$. At such partition structure of $\mathbf{S_0}$ system is hierarchical (Fig. 4). System $\mathbf{S_0}$ is a (system-) model of realisation of decision process and exists only in abstract form. Process $\boldsymbol{P_D}$ is of course realised in physical systems. In paper only one of physical systems, system **BS** is analysed.

LEVEL 2. SYSTEM OF PROJECTING BUILDING - DBS

Structure of definition of **DBS** system is the same as definition of system (1) [2,5]:

$$\mathbf{<x,m> \in DBS \Leftrightarrow } \boldsymbol{P_{DB}}\mathbf{(x,m) \in M \wedge \exists\, m^* \in M} \quad (3)$$

given by

$$\mathbf{K\,[x,m;\, } \boldsymbol{PB_D}\mathbf{(x,m^*)] = min\, K\,[x,m;\, } \boldsymbol{P_D}\mathbf{(x,m)]}$$

with:<x,m> - couple,

$x \in \mathbf{X}$ - entry set (project foundation - exits from subsystem $\mathbf{S_{01}}$, relations with environment [Fig.5], relations with subsystems $\mathbf{S_{03}}$,$\mathbf{S_{04}}$**),**

$y \in \mathbf{Y}$ - exit set, (project of building: function, form, parameters)

$m \in \mathbf{M}$ - set of variables,

$\boldsymbol{P_D}$: $\mathbf{X \times M \Rightarrow Y}$ function of process, (projecting process)

$\boldsymbol{K}$: $\mathbf{M \times Y \Rightarrow V}$ object function, (criterion of project estimation)

V – object of valuation

For evaluating of process **PD** problem of optimisation is solved. In set of criterions $K \in \boldsymbol{K}$ main ones are criterions (2).

- **Problem of optimisation :**

Data: X - space lineal

$K\,(m \in X) : X \rightarrow R$

$m* \in V$ should be estimated so:

$$K\,(m*) = \min_{m \in V} K\,(x,m) \quad (4)$$

$$V = \{\, m:\ g\,(x) \geq 0 \,\}$$

where:

$g(x) \in G$ - set of limitations

2. ANALYSE OF OPTIMISATION CRITERIONS

2.1 General analyse of minimalization of waste of energy criterion

The criterion has been accepted in following form:

$$\min ZE(y,m) = \min [ZEr(y,m\} + ZEe(y,m) + ZEm(y,m) + ZEu(y,m)] \quad (5)$$

in same cases the cryterium can be replaced by cost criterion:

$$\min K(y,m) = \min [Kr(y,m) + Ke(y,m) + Km(y,m) + Ku(y,m)] \quad (6)$$

where: ZE ,ZEr, ZEe ZEm, ZEu - ZE, ZEr,ZEe - energy demand: total, for realisation and exploitation, modernisation and demolition
K, Kr, Ke - total cost, cost of realisation, of exploitation, modernisation, demolition.
In general this criterions are equivalent.
In both forms the function of aim is a function of time. In special cases variable **t** can be replaced by a parameter (eg te- time of exploitation, tz - time of refund of additional outlays).
As partial criterions in function of aim are contradictory ones, the problem has to be formulated as a problem of multicriterial optimisation [3,6].

2.2 Details

1 Element of function of aim connected with realisation of object (both ZEr and Kr) has always additive form which makes possible presenting it as follows:

$$Kr(y,m) = \sum Ki(y,m) \quad (i = 1,2,,,n) \ (n \text{ - number of units of object}) \quad (6)$$

and leads to decomposition of this parts of problem.

Moreover, in some cases it can be accepted that:

$$Kr(y,m) = \sum Ki(y,m) + \sum Ki(y) \quad (7)$$

which limits number of partial extreme problems. It enables also estimation of correctness of problems formulated separately for each unit of object.

2. Element of function of aim connected with exploitation of object can represented as follows:

$$Ke(y,m) = KE(y,m) + KU(y,m) = ke \bullet \{ Eu + \Delta E - Eo \} + KU(y,m) \quad (8)$$

Where:
KE - cost of energy
KU - remaining costs of use /eg. connected with durability of accepted solutions/
Eu - effectively used energy
ΔE - losses of energy in installations of object
Eo - effectively used renewable energy
Ke - elementary cost of energy

Let us notice, that in general:

$$\Delta E = \Delta E(y,m1) \quad ; \quad Eu = Eu(y,m2)$$
$$m_1 \in M_1 \quad ; \quad m_2 \in M_2 \quad \bigcap M_i = \varnothing \quad (9)$$

so problem of minimisation of losses in object's installation (maximization of installation efficiency) can be considered as independent one. Instead, effect in form of installation cost should be taken into account in Kr. However, on the ground of (9) initial problem can be considered as decomposited. Similarly KU(y,m) can be taken into account in Kr.

3. So, without loss for generality of solution function of aim can be presented as follows:

$$K(y,m) = \sum Kri(y,m2) + \sum Kri(y,m1) + ke * [Eu(y,m2) - Eo(y,m2)] \quad (10)$$

which leads to function of aim:

$$K(y,m) = \sum Kri(y,m2) + \sum Kri(y,m1) - ke * Eo(y,m2)$$

$$K(y,m) = ke * [Eu(y,m2) - Eo(y,m2)] \quad (11)$$

3. DECISION VARIABLES (IN PROCESS OF PROJECTING OF BUILDING)

- **STRUCTURE OF SET OF VARIABLES M**

Features of object /those, which did not become explicitly defined in project foundations/ are decision variables. In every, general enough, problem of projecting optimum, in set M can be done partition into classes:

HAS = {m - describing shape, form of object}

MB = {m - describing parameters of object} (12)

Sets of variable values $\mathbf{m \in MA}$ can be defined by ascription their forms to set of coefficients **I**. Set of values V**MA** of all variables belonging to **MA** is defined as follows

$$VMA = \overset{n}{X} VMAi \qquad (n - \text{power of a set MA}) \quad (13)$$

Units of this set can be treated as values of vector variable $\mathbf{m_a}$ characterizing shape /form, class/ of object.

It can be proved that the **VMA** set is a finite set, non-enumerable and not well ordered [6], and representation:

$$K : Y \times MA \rightarrow VA \subset V \quad (14)$$

does not define in VA arranging relation. So, this settlement of set VA is only possible by comparison. In consequence every, general enough, problem of projecting optimum can be presented in form of problem having at least two planes.

$$\min K(y,m) = \min_{m \in MA} \{ \min_{m \in MB} K(y,m) \} \quad (15)$$

Moreover problem of lower level decomposes on n - independent problems.

- **MA** SET /OF INOBTRUSIVE, ISOLATED VARIABLES/

Number of variables capable to occur in this set depends of course from a problem. In investigative problems one should rather tend to widening of set which is a requisite for generality of problem. In practical project problems set is generally narrowed in fundamental manner eg. through taste of investor or stylistics of architect. However at least for energetistic estimations of projected object it is purposeful to endeavour after extension of set at least at formulating of problem.

- SETS **MB**

Representation can be defined:

$$\alpha : VMA \rightarrow MB \qquad (16)$$

attributing values of vectorial variable **ma** with subsets MBI. So, opening at general problem /regarding variables which belong to both sets/ problems from bottom level are also defined.

2. Variables characterizing parameters of object are in natural way connected with components, which in structure of object always can be distinguished. In the face of this set MB can be examined as sum of sets attributed to each component:

$$MB = \cup MBi \quad (i=1,2,,,n) \quad n\text{ –number of units /components/} \qquad (17)$$

Defining set:

$$MBo = \cap MBi \neq \varnothing \qquad (18)$$

we receive set of co-ordination variables. Function of aim for problem of can be presented as follows:

$$\min K(y, mai, mb) = \min \{ \min_{ma} \sum_{mb} Kj(y, mai, mbi) \qquad (19)$$

which makes possible decomposition of problem. In particular case when **MB**o = ∅ we receive n independent problems.

4. FINAL REMARKS.

- Proposed approach makes possible solving of complicated problems by bringing them to partial problems, without necessity of using simplifying foundations because, at formulating of problem, a real structure of object under optimisation is used. Formulating problems in categories of system theory seems to be very effective here.

- During presentation of the paper examples of obtained solutions will be presented.

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Indirect Passive Solar Use in Central Europe – Preliminary Studies

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1. INTRODUCTION

One of the most important features of the sustainable building is its significantly reduced consumption of conventional energy and increased use of unconventional energy sources. The passive solar systems appear to be the most promising and simplest way to absorb, accumulate and utilize solar energy in buildings.

Trombe wall, i.e. indirect passive solar system, is usually associated with the sunny climates of southern Europe or New Mexico, USA. Unfortunately, there is no reliable and evidence documenting the thermal efficiency of such a system in Central Europe. Also, the empirical design rules for such locations are yet to be developed. That is why this system (and other passive systems) is now the subject of the author's comprehensive research, reported only in a small part in this paper.

Computer simulation of the seasonal thermal behavior of buildings has become an important design tool, nowadays. Even functioning of very complex physical systems, like the building itself, heating and ventilating installations, can be simulated step by step in the non-stationary environmental and internal conditions. While it is not possible or reasonable to simulate every designed building in this way, this tool may be extremely useful in the case of new technologies, architectural ideas or outstanding energy saving measures. Computer simulation is a valuable research tool, allowing to develop and investigate the precise design rules for engineers.

One of the largest and newest simulation tools is, nowadays, an American program called Energy Plus, which was released by the American Department of Energy, its agencies and the other cooperating institutions in April 2001.

2. ENERGY PLUS: GENERAL OVERVIEW

Based on a user's description of a building in terms of physical make-up, associated mechanical systems, etc., Energy Plus will calculate the heating and cooling loads necessary to maintain thermal control setpoints, the energy consumption of primary and secondary plant equipment as well as many other simulation details.

The main features of the program, Crawley et al. (2001):

- Integrated, simultaneous solution for the heating system and building response
- Sub-hourly, user-definable time steps
- ASCII text based weather, input and output files
- Heat balance based solution for thermal zones and separate, heat exchanging surfaces
- Transient heat conduction and combined heat and mass transfer
- Thermal comfort models (Fanger, Pierce, MRT model)
- Anisotropic sky model
- Advanced fenestration calculations, including controllable window blinds or night insulation, electrochromic glazing etc.
- Daylighting controls
- Loop based configurable HVAC systems (convective or radiant).

Energy Plus is not a user interface. It was intended to be a simulation engine around which a third-party interface can be wrapped. Inputs and outputs are simple ASCII texts, that may be easily read and modified in the usual word editors. Geometrical data of the building is exported to a dxf-format file, which is read in AutoCad or Volo-View-Express. Calculation results are gathered by the postprocessor in a csv-format file, that may be read or analyzed in Excel.
Weather data may be introduced in two different ways:

- design-day; described by average temperature and its daily deviation, usually used to model the extreme conditions
- annual; hourly data of temperatures, radiation, wind etc. in special Energy Plus format, (data of TMY2, WYEC2 or BLAST format may be easily converted) used to simulate the user defined period of the year.

European weather data, used in the simulations presented, was provided by Linda K. Lawrie of the US Army Construction Engineering Research Laboratories.

3. ASSUMPTIONS

The simulated building consists of the three thermal zones, the Trombe wall is located in the south-west zone. It was assumed that:

- the simulated zones are thermally separated and there are no internal heat gains other than sun radiation and the purchased air heating system
- the whole opaque envelope of the lightweight building structure is well insulated, thermal conductance of the wall is 0.249W/(m^2K), roof 0.165 W/(m^2K) and floor 0.245 W/(m^2K).
- the unvented Trombe wall is located behind the very large, double and unshaded glazed opening; modified within the simulations,
- the neighboring south space is a reference thermal zone with the super insulated (zero loss) wall in one case and the standard window and glazed door in another,
- the minimum internal air temperature is set to 20°C and the maximum to 28°C
- the amount of purchased heating energy is the measure of the passive system's thermal efficiency
- heating simulation period: 15.IX – 15.VI, four timesteps in an hour
- the same building is located in Warsaw, Berlin, Hamburg and Stockholm
- ventilation rate is constant and equal to: ca. 0.5 ac/h in the both south zones and 0.4 ac/h in the north zone.

3. TROMBE WALL ACCUMULATOR FEATURES

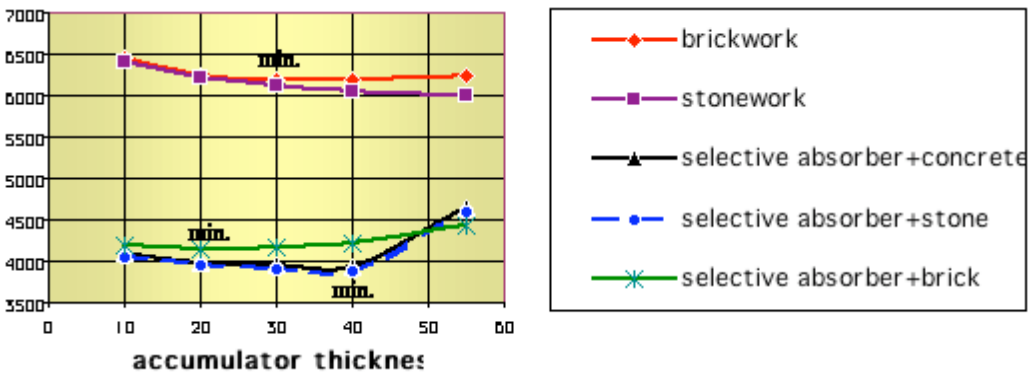

Figure 1 Seasonal space heating demand in Berlin vs. accumulator thickness

The aim of the first few simulations series was the optimal thickness of the heat accumulator. The achieved results, Fig.1, reveal that the optimal thickness (minimum of the seasonal heating energy demand) of the simple brickwork wall in Berlin is 30-35 cm and decreases to 20 when selective coating is introduced. It should be noted that the storage capacity of the Trombe wall is not merely a function of the wall thickness, but also depends on heat conduction, material specific heat and surface spectral features. In the case of well conducting materials as concrete or stonework, the absolute minimum is even beyond 50cm. Because of insulating and accumulating functions of the wall, its sizing is also related to the environmental load, Balcomb et al. (1984). This assumption is confirmed by the data shown in Fig.2. The colder climates of other locations, increase the optimal storage thickness of the brickwork accumulator to 40 cm for Hamburg, 55 cm for Warsaw and beyond 55cm for Stockholm.

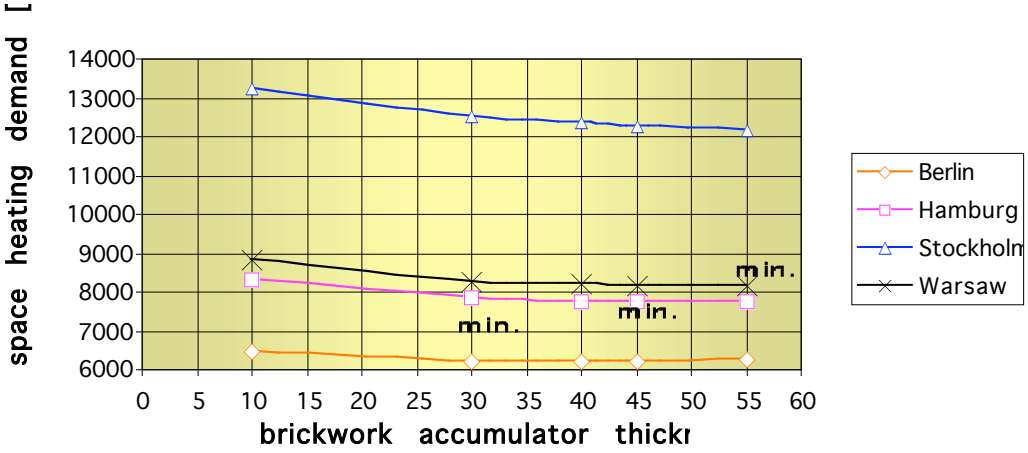

Figure 2 Seasonal space heating demand vs. brickwork accumulator thickness in north Europe locations

Nevertheless, it must be observed and firmly stated that the calculated differences of the heat demand are, in all the above cases, insignificantly small (ca.3%) for the conventional accumulators within the thickness range of 20-55cm.

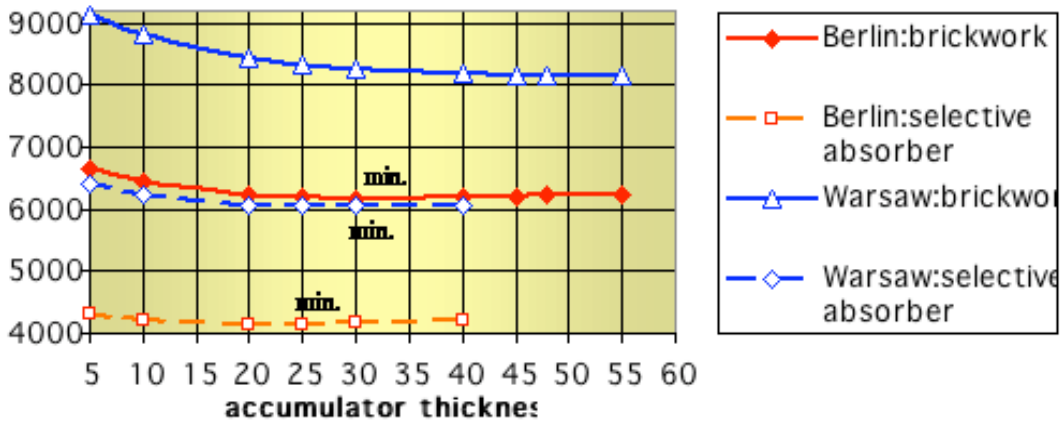

Figure 3 The collector wall with the selective absorber

The really significant reduction of heat demand may be achieved by means of a selective absorber, covering the external surface of the accumulator, Fig.3. Extremely low emission of thermal radiation (ε_{th} = 0.05) allows to decrease the seasonal heat demand of the zone even by 32%. The relatively thin layers of accumulating materials (15-25cm) behind the selective absorber provide in this case enough storage capacity.

The conducted simulations proved that in Central European climates:
- accumulator material and
- accumulator thickness

do not influence the system's efficiency in a significant way, unless a high-tech selective absorber is introduced. Optimal accumulator thickness is a result of a compromise between the storage capacity and Trombe wall insulating features. In colder regions, thicker walls protect better against heat loss rather than absorb effectively and accumulate solar energy. The heat capacity parameter that is directly related to annual energy saving performance was called by Balcomb and Wray (1987) effective heat capacity. Optimal values of the collector thickness are quite different for the diurnal and annual periods.

An important and sometimes underestimated factor of the passive systems is risk of overheating. Seasonal cooling demand of the space adjacent to Trombe wall in Berlin is shown in Fig.4, for the 28°C setpoint. Optimal conventional accumulators, as defined above, minimize the intensity of overheating (in heating season) to an acceptable level. Special attention should be paid only to the more efficient systems with the selective absorbers.

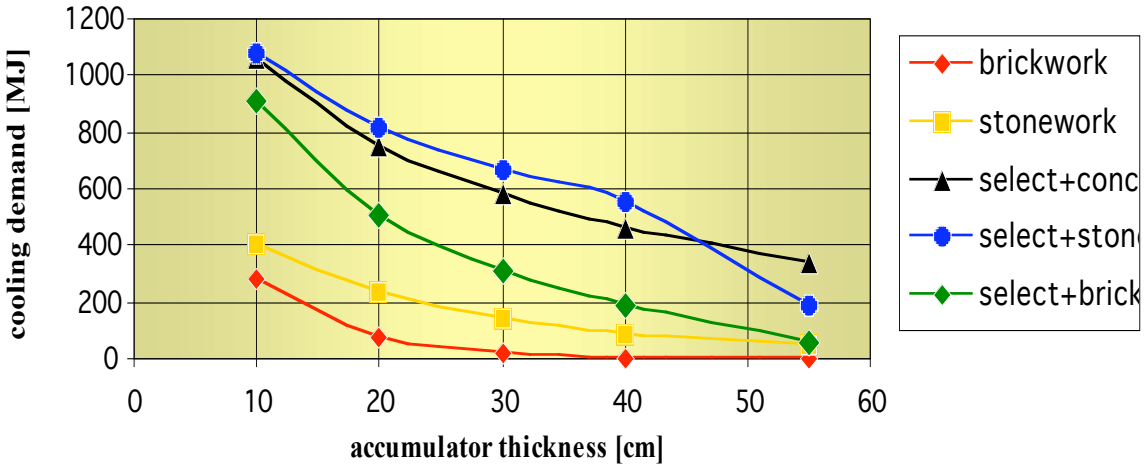

Figure 4 Cooling demand of the space behind the collector wall, Berlin

Significant overheating problems may happen in Berlin only in the case of a highly selective absorber covering the accumulating wall. For other systems and other locations there is no substantial risk of overheating.

5. SYSTEM MODIFICATIONS

The influence of other factors on the space heating demand is shown partially in Fig.1, 3 and in Fig.5. The most efficient system, for the four investigated locations, is the Trombe wall with selective absorber (A). It is followed by the simple brickwork accumulator (B), which is protected by double low emissivity glazing with krypton in between and then conventional glazing with night insulating shades (C). In the case of Berlin, Hamburg and Warsaw, even

the simplest systems with brickwork (E) or stonework (D) accumulators with normal double glazing work well and prove to be energy efficient, i.e. the total seasonal heat gains overcome the losses. A significantly increased energy delivery to the zone is needed in the case of the reference zero loss opaque wall (F) or standard window in the south wall (G) instead of the indirect passive system.
In the colder climate of Stockholm the simple, poorly insulated Trombe wall (D and E) is not thermally efficient. Only the more advanced Trombe wall systems may be advised in those conditions.

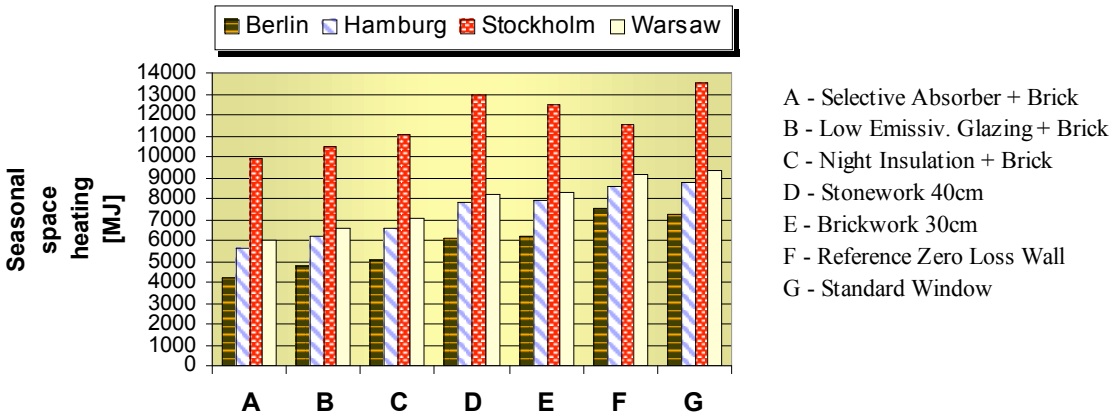

Figure 5 Seasonal heating demand of the zone vs. various arrangements of the collector wall

It must be noted that in case G, i.e. the standard window and fully glazed balcony door in south wall of the analyzed space, the thin gypsum plaster on the walls provides enough thermal capacity to absorb solar energy and to protect the space against overheating, Kisilewicz (2001).

6. SOLAR HEATING FRACTION

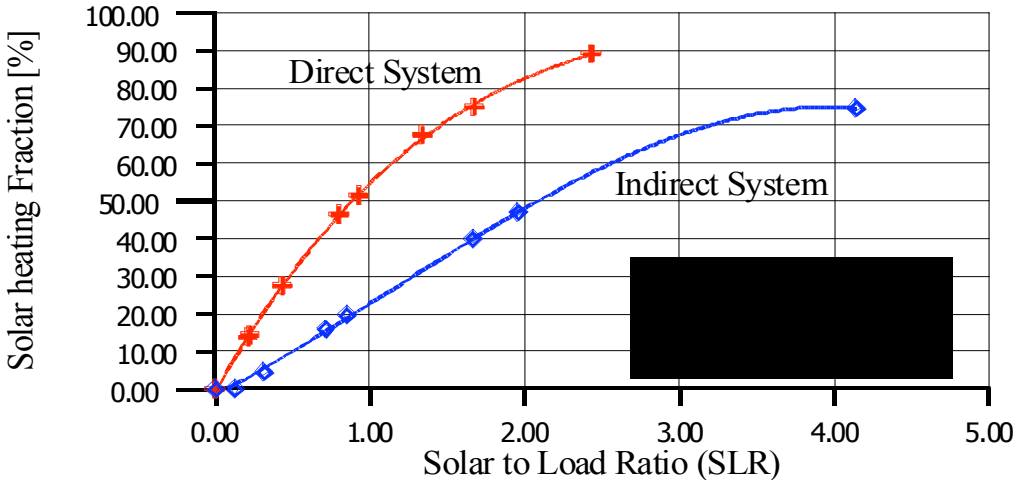

Figure 6 Solar heating fraction (SHF) vs. solar to load ratio (SLR) for standard glazing

Solar heating fraction of the passive system is the simple way to describe useful solar gain or expected energy savings. Above presented correlation was established by using computer

simulation to predict the thermal performance of the investigated building on the monthly basis. In this way various climatic conditions were analyzed. The graph may be used to predict the annual performance of the passive system on the basis of the calculated. average yearly SLR value.
Conducted simulation confirmed that the thermal efficiency of the south oriented glazing is much bigger than the efficiency of the collector wall.

7. CONCLUSION

The simulation program called Energy Plus, which was released by the American Department of Energy in April 2001 is nowadays one of the largest and newest simulation tools. It was used to simulate thermal effectiveness of the indirect passive solar system: collector wall, located in the few different places of the central Europe.
The results obtained for the long term simulations confirmed that the optimal thickness of the storage wall is related to the material features and local climate. In colder regions, thicker walls protect better against heat loss rather and absorb effectively and accumulate solar energy.
The thick accumulators minimize also the intensity of overheating (in heating season) to an acceptable level.
In the case of Berlin, Hamburg and Warsaw, even the simplest systems with brickwork or stonework accumulators protected by the normal double glazing work well and prove to be energy efficient. The most efficient indirect system is the collector wall with the highly selective absorber on the outer surface. The bigger values of SHF may be obtained in the case of the direct passive solar system.

Acknowledgment:
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Educating for Sustainability

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1 INTRODUCTION

This paper will address the development of a new 3-year study programme Environmental engineering at Oslo University College, Faculty of Engineering. The paper will briefly cover (1) the external incentive for developing it, (2) the developing process, (3) the programme contents with focus on sustainability and (4) how we organise the learning process with extensive use of project work and focus on "sustainable" knowledge.

2 EDUCATING FOR SUSTAINABILITY

2.1 External incentives for developing a new study programme

The large amount of resources an institution has to invest in the process of developing a new study programme is an indication that the process has to be justified. Reasons and arguments for such a process can be found both within the organisation and outside it. In this case I would like to emphasise that there has been several external incentives pushing for a new study programme, such as:

- The development in the energy and the environmental situation in the world
- National and international environmental politics strongly suggest the need for increased allocation of resources as well as new technical solutions
- Cheap energy in Norway has led to a lack of knowledge and competence within the areas of energy saving and alternative energy
- Industry has announced the need for multidisciplinary competence. Energy and the environment must be linked to processes, building and technical installations. The ability to cooperate in multidisciplinary teams and to manage such cooperation is considered important
- An external commission that has evaluated the department of Mechanical Engineering at Oslo University College recommended that we focus on energy and the environment
- Other institutions in Norway educating engineers confirm that the need for this kind of engineer is not covered by the existing study programmes in other places

To put it short, through organisations, public funding, mass media and conferences like this we have seen the need for a new kind of engineer to help society reach its goals regarding sustainability in buildings. This educational program is a direct consequense of the external demand for sustainable buildings.

2.2 Developing a study programme

Regular engineering education in Norway has to comply with a quite strict set of national framework regulations. This means that every engineering student in Norway has to learn a certain amount of maths, physics etc. A new study programme must comply with the same set of rules and regulations. This of course sets some limits as to how free and radical the contents of the new programme can be.

When deciding on the contents for the new programme we started by asking industry and industrial organisations what competence the new engineer should possess when entering his first job after school. According to the documents produced after discussions with industry he/she should "*be able to take responsibility for and later lead activities that aim at comprehensive solutions for buildings and construction processes in such a way that the solutions satisfy demands for energy use, the internal and the external environment, functionality and economy*".

Then came the process of breaking this down and proposing subjects to match this goal. Again industry played its part and an interesting process resulted in at least one fact. One engineer cannot master all aspects of environmental issues in buildings, meaning that the new study programme will offer some mandatory courses and some choices for the students to make. One of the bigger decisions for the student will be the choice between energy or environmental focus in the later stages of the programme. Learning how to reach comprehensive solutions means that you inevitably have to communicate with professionals with knowledge and qualifications different from your own.

To start with the sixth and last semester in this 3-year study programme. Students in their last semester will work on real industrial projects with students from other study programmes – i.e. economies, architecture etc. This way we hope to provide industry with environmental engineers ready to face the often difficult task of communicating with other professions. In an educational setting this can be addressed as the problems arise, in real life this will often become more problematic.

Further down the line we find semesters 4 and 5. In both these semesters students will have to make a choice of which direction they want to follow. This brings us to the fifth semester. Students will choose between energy or environment in buildings. But remember that these students will meet each other again in projects during semester six, so it is a temporary split. The fourth semester hosts a similar choice, this time between Electrical Technique and Indoor Climate. This does not however mean that students are divided into groups without communicating with each other. Communication skills are regarded as important, hence some of the subjects are common for both groups. Projects from industry and projects or cases of relevance for both these classes will unite these students in a common search for solutions. Even though they have chosen different paths they can still work on the same projects and problems.

What about the first three semesters of this new study programme then? I have already mentioned the strict framework engineering education in Norway has to comply with. The question now is how do we get a consistent study programme within this framework? We have tried to break down maths, physics and other mandatory subjects into smaller parts. After the projects are described lecturers try to link parts of the mandatory subjects to the projects. This way we will focus on the parts of the mandatory subjects that the students immediately can experience as useful for their studies. If we succeed with our plans it will probably be the first successful integration of mandatory subjects and the other subjects in Norway at a large scale since the national framework was established some years ago.

Through the development process we also found it necessary to create new subjects to support the general idea of this study programme. One of these subjects is especially created to handle basic environmental issues. Here we will emphasise a broader and more comprehensive view

on the environment than what will normally be perceived through the other subjects. The title of this course can be translated into "*Energy and environmental knowledge*".

As for developing something new I think we can state very clearly that the development of this study programme is not a classic excample of "*same shit, new wrapping*" ideology we meet so many places. This is a new study programme with new subjects and new aims. When the inauguration class can respond to what and how they are learning I am sure we will have to adjust and redevelop the study programme. But so far we think we have managed to create something new, exciting and useful.

2.3 Multidisciplinary engineering education

Multidisciplinarity from the very start. How is that possible? From a conservative point of view the answer would probably be - it's not. That is however not how we see it. On the contrary, we believe it is both possible and necessary to start with subjects that grasp the comprehensive picture when it comes to environmental issues in buildings.

The first task for students in this respect is a simple one. Take a step out in to the real world of schools, kindergardens, office buildings, private homes, industrial premises, architects' offices etc. Before we start teaching mathematics, physics, chemistry etc. we will send the students out with one main task to solve. Collect, bring back and present information about which problems people face on a daily basis regarding environmental issues. This will most likely provide students with quite a broad perception of some relevant environmental questions they need to address when they have finished their three years of education. As a matter of fact, they need to address these questions from the very next day and throughout the next six semesters of study.

Looking at the study programme it may seem like a regular programme. Comparing it to other programmes reveals that it is not. The main difference can be found in the very important principle of 50% project work throughout the programme. Traditional teaching methods with blackboard and chalk will still be present, but to a much smaller extent than you would expect. The main idea of doing many projects is that parts of the different subjects can be taught together where they are relevant, as long as they are linked to a project or a specific case. So the projects are of great importance here. And the projects will of course have to be relevant. Not necessarily real industrial projects in the first semesters, but very likely in the last semester or two. But it has to be relevant, addressing real problems in a real world.

2.4 The learning process

There is a general progress in what we want the students to focus on throughout the study programme, and this is reflected in the fact that each semester has its own general theme. The present themes for six semesters can be described like this in English:

1. Environment is the goal - energy is the means
2. The good sources
3. The good tools
4. The good techniques
5. Energy or the environment
6. Students in team

There will be two big projects each semester to ensure that during the first five semesters students will participate in ten projects of a certain size. During these projects the different

subjects will be brought into play *when they are necessary for solving problems*. And this is of great importance. Even though some subjects will be taught on a regular basis, week in and week out, they will be adjusted to the projects one way or another. Even maths, statistics and physics, important base subjects will be linked to the projects. So will the other subjects.

By organizing the study programme this way we hope to make both the professors and the students more aware of the big picture - not just focusing on passing an exam in each subject. The question of exams brings us over to a another interesting aspect of this study programme. The student assessment procedures. A lot of the learning process for the student is tied up to working with different projects. In the new study programme we will assess the students knowledge and understanding of the different subjects in at least three different ways.

a. the regular, good old exam
b. assessment linked to projects
c. multiple choice testing throughout the year

Through these extensive assessment procedures students will learn to appreciate the views of other students. Some of the final grade students may even adjust themselves to how the group perceives the process and each group member's contribution to the different tasks involved in the project. Knowing that counselling will be given on a weekly basis ensures that lecturers and students communicate on a regular basis. Misunderstandings regarding contents and subjects can be addressed immediately hence all the students should gradually experience improved understanding of both the individual subjects, and also a more comprehensive understanding of energy and the environment.

To further ensure that industry can benefit from these candidates immediately after their final exam we will focus on project management tools from day one. Each student will of course be given specific dates (for examination, project starts, project ends etc.) but they and the groups they belong to will have to structure their own scedules a lot of the time, knowing that regular lectures are cut down to a minimum. The students will of course be given the lecturing dates as well, but as in real life we will spring a surprise or two during each semester. These little extras will most likely be short notice guest-lectures from industry and organisations, or visits to interesting locations and events in the local area of relevance to the study programme. We intend to do our best to provide each group with the little special lectures that they request for their project. It would surprise me greatly if all the other groups and students would not also find this interesting. But that remains to be seen. All students will have to respond to changes and offers like this. Life for the students will look a lot like the life they will meet in their first job.

3. A SUSTAINABLE STUDY PROGRAMME?

It is my statement and belief that both contents and organisation of this study programme in Environmental engineering will produce candidates capable of participating with great success in creating and maintaining sustainable buildings. In the last part of my article I would like to emphasise that in my opinion both contents and the learning process are based on the three objectives for the conference "Sustainable buildings 2002".

We start with **The Challenges**. Students will be met with challenges through visits to relevant places and by meeting inspiring people from industry and other relevant organisations and places. They will need this basic knowledge about the challenges they will face through their studies and professional life. Furthermore *we* regard it a *challenge* to motivate the students and to try to influence their attitude towards comprehensive solutions. Working on the students' attitudes will probably be our biggest professional challenge as educators.

Cooperating with others will also often be seen as a challenge, but here the students will have to face this from the very first few days. Considering the contents, the environment will receive a lot more focus than energy the first period of this study programme.

Through aquisition of **The Knowledge** (and tools of the trade) we expect the student to acquire ample skills and knowledge in order to produce **The Solutions** (to a certain extent alone, but also as a project group participant and maybe even leader).

Industry wants candidates with both technical skills and a comprehensive view of the environmental side of buildings. And industry wants a positive environmental attitude amongst their employees. Society wants sustainable buildings and Oslo University College wants happy customers (students and industry). We sincerely believe that this new multidisciplinary study programme in energy and the environment will deliver the goods.

The Park City and the City in the Park – new urban Development of the City of Warsaw Case Studies

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SUSTAINABILITY OF THE CITY OF WARSAW

The idea of sustainable development and sustainable city has no alternative at the beginning of the XXI century. Implementation of the general idea of sustainable city might be various and should be different, as the locally based diversification is one of the principles of sustainable development. Every city as a whole and as specific city districts has to find its own way of meeting the sustainability requirements according to its identity and local conditions in the broadest meaning of those.

The urban development of the city of Warsaw starting from the first modern plan dated in 1916 and being continued in all master plans since then was based on an idea of regional balanced hierarchy between urbanised and open green areas. The regional balanced hierarchy used to describe the Warsaw spatial model follows terminology used by Haughton (1989). After 1945 on top of this general idea the modernistic zoning of separating housing, production and city centre activities to be developed between the green corridors of the city ecological zone was introduced. Due to this policy Warsaw mono-centric structure, where still a vast majority of working places are located in the city centre and effective public transport system is rather weak, creates typical problems of car orientated and functionally segregated city. But also due to this policy Warsaw is recognised as a green city. This image of Warsaw is based on many historical parks as well as parks and recreation areas developed in 50s and 60s but mainly on undeveloped ecological zone, which in shape of green corridors penetrates the city structure from the suburbs to the city centre. Allocation of ecological corridors of Warsaw is connected with the main natural landscape features which is the Vistula river and river valley escarpment. Warsaw open areas serving as the reservoir of fresh air and natural neutralisation of the city air pollution were mainly designated for agricultural production within the city. Even when a good part of these areas became vast lands as the economical effectiveness of agricultural production dropped down, they were protected from urban development according to the city master plan. Beyond the plan, the centralised political and economical system in Poland and the lack of potential for dynamic development of the city until 1989 were the safeguard against the urban sprawl into the green areas.

The significant year of 1989 is not only the beginning of the new European international relations and of the new historical area of Poland, but also it creates new conditions for urban development of the city of Warsaw. The conditions meeting requirements of the free market economy and social hopes for better life and living conditions. The new master plan of Warsaw adopted in 1992 was a very fast reaction triggered by the political changes. The main idea of the plan was opening Warsaw for new dynamic development, which resulted in designating much more area for urbanisation than until now and in leaving the minimal ecological zone not to be built up. After nearly 50 years of strictly controlled urban development, hundreds of hectares of ecological zone became at once a new urbanisation

offer. Areas along the river and the river valley escarpment are promising exceptional living conditions close to the most beautiful natural landscape and within the city. But on other hand reducing the green zone to the minimal ecological corridors endangers the city sustainability.

The present land use structure of Warsaw shows that 21% of the city area is designated in the plan as city greenery and the 23% of the city area being agricultural lands are designated for new development. This data, according to master plan of Warsaw 2001, shows that Warsaw may loose more than half of its open lands which is a threat not only for living conditions in the whole city, but also for the cityscape identity.

We believe, that any new urban development, when the sustainable goals are principles, may not only be as much as possible less harmful for the nature, but also can enrich the city structure. It can also influence the better functioning of the city and may compromise the group and private and the whole city and public interest.
We present below the case studies of sustainable urban development of two districts of Warsaw, which various local conditions required different implementation of the same general ideas.

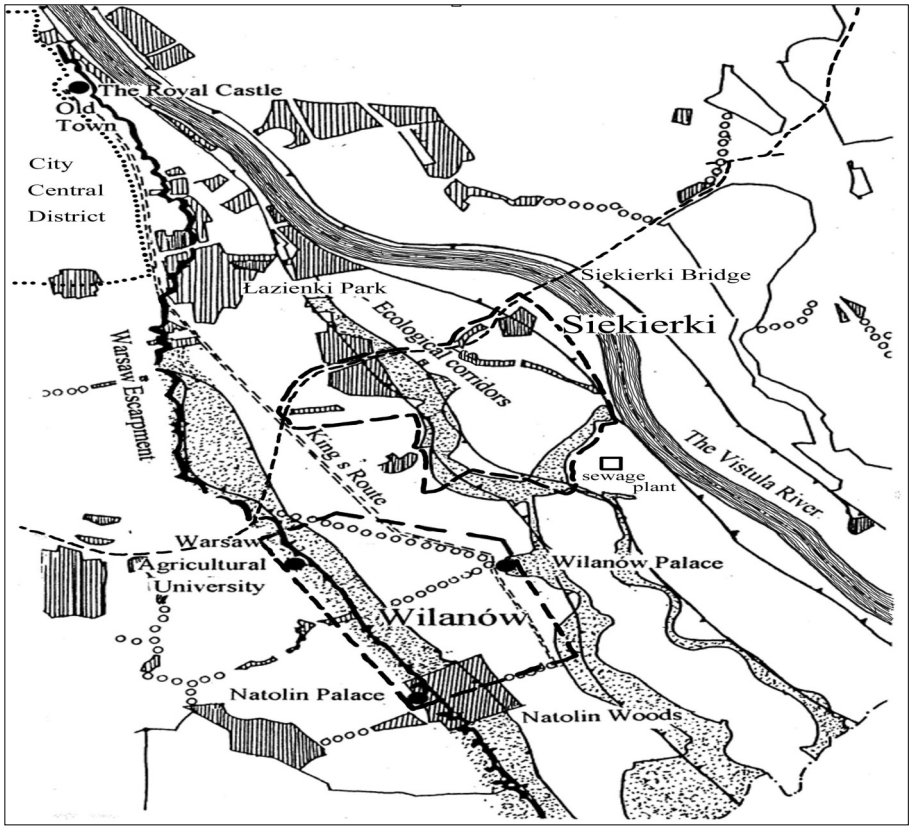

Figure 1. Wilanów and Siekierki within the structure of Warsaw

THE WILANÓW PARK CITY

Wilanów is the area of approximately 500 ha on the south edge of the city, 8km from the city centre. The area is located between two ecological corridors, close to Warsaw escarpment, and until now it serves as farming fields of the Warsaw Agricultural University supporting its research activity. The Wilanów Park City Case Study was a competition entry awarded 2nd prize in 1996 and published in Staniszkis 1997. The open fields in front of the Wilanów Palace are an important part of the cultural heritage of this place and its genius loci as well as the low density housing development space in vicinity of this area. The Wilanów fields are

now beyond the reach of the city central sewage system not only because of the lack of the local and main sewage net. Development of the communal sewage system in this area is conditioned on construction of a new sewage plant of southern Warsaw and of the whole system of main sewage conduits servicing this area.

The first goal of the plan was to preserve as much as possible of the city wide climatic role of the existing open fields. In a situation when the city authorities are not willing to develop public greenery open spaces also due to insufficient city budget, the plan proposed very low development density and very high percentage of biologically active land on every single private or public lot within the whole area. The average percentage pertaining to all kinds of land uses is 80%, 70% in the district centre and above 90% in the vicinity of the surrounding ecological corridors. Private gardens, instead of being treated as contradiction to the public interest, are treated as a public benefit for the natural environment protection.

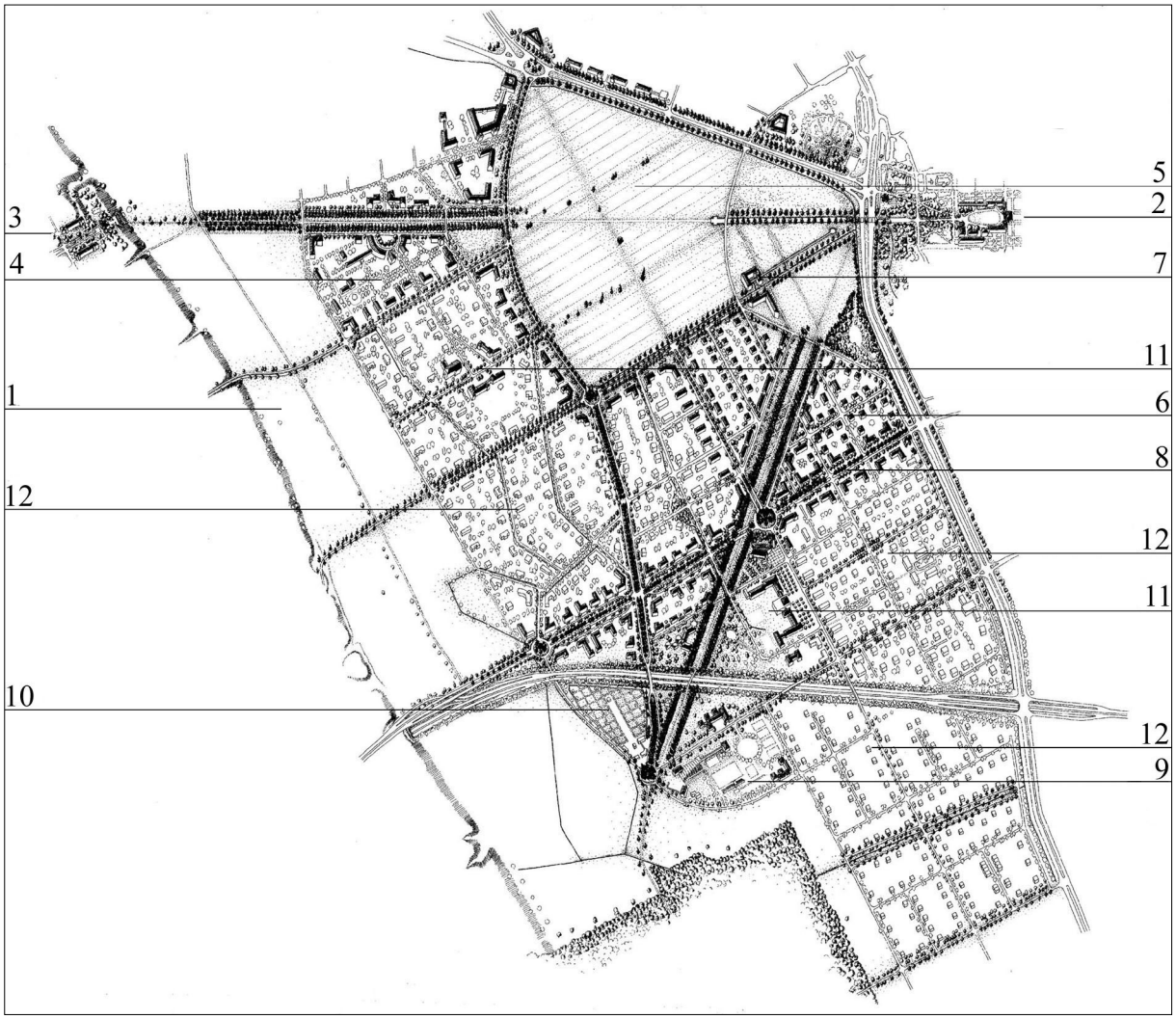

Figure 2. The Wilanów Park City. 1) Warsaw escarpment ecological corridor 2) Wilanów Palace 3) Warsaw Agricultural University 4) new campus 5) Agricultural Park 6) Wilanów Centre 7) Town hall 8) Business Park 9) Sports Centre 10) Cemetery 11) Neighbourhoods centre 12) Housing areas

Another point of the Park City is the new cityscape type. Instead of traditional streets, squares, piazzas, markets and street crossings, there are alleys with tree rows, public city

gardens, smaller and bigger city parks and green roundabouts of various size, with the ever presence of nature in public space. Public gardens and parks, edged by the traditional city centre programmes are formed as corridors of approximately up to 100 m. wide, along the historical composition axis connecting the Wilanów Palace with large public parks on the Warsaw Escarpment. The historical composition is not only preserved but also used as the district public activities core.

The culmination of the idea of the City Park is a proposal for the 50-hectare agricultural park in front of the Wilanów Palace to conserve the landscape genius loci and to continue the tradition of the Warsaw Agricultural University. Development of a new campus is also proposed along the axis connecting the existing palace of the University with the Wilanów Palace. The agricultural park, really used for advanced experimental farming, park with public paths and alleys between the grain fields might not only be a landscape attraction within the city. This type of land use in the city can also play a socially educational role of reminding the big agglomeration inhabitants that the nutrition is before the shelter, according to Vale (1993), that balance between manmade city and nature is the point of our survival on the Earth. The educational role of the living environment, in the sense that our behaviour is partly dependent on the place where we live, is stressed by many authors including Rappaport (1977).

High percentage of not built up areas and low building height typical for a suburb even in the district centre, creating atmosphere of the city or rather small town under the trees, has not only the symbolic role of stressing the natural environment importance. The low built up density of the district from 0,25 of the villas' sector and 0,5 in the standard housing to 0,7 in a district centre is a solution to technical development barrier being the lack of the central sewage treatment system. According to the city plans, development of Western Wilanów is limited to maximum 13 thousand inhabitants. This, in the area of 500 ha, will result in a low gross density, therefore the cost of the central sewage system per unit would be anyway high.

The City Park plan proposal is based on the local, ecological, and appropriate to local conditions sewage treatment plants on every lot, so that the low density meets requirements of such solutions. The situation when every user is responsible for its own sewage is not only a more economical solution for such a specific area, but also the way of developing social consciousness of responsibility to the nature and to the local community. Decision of basing urbanisation on the local, but environmentally safe, sewage treatments makes the development possible from now on, meeting developers' expectations.

The idea of Wilanów Park City is to show that idyllic, close to nature living environment is not only for the luxury suburban housing, where most inhabitants spend half daytime on commuting to work or to the city activities centres. The Wilanów Park City plan is a proposal for mixed use of all city activities and wide range of housing types from villas on sizable lots, the family and town houses on the smaller lots, as well as small blocks of flats.

The district centre organised around the central park is composed of the traditional city centre programmes, but of lower density. The business park is an integral part of the Park City structure. Schools, civic centres and small parish churches within walking distance organise social life of approximately every 5000 inhabitants. Sports and a leisure centre are located along the public linear park as well as a small cemetery to complete all human needs. This approach closely matches the idea of mixed use development described by Calthorpe (1993).

The programme of Wilanów is to serve much more inhabitants than planned for this area. Wide range of land uses and new working posts proposal has the city wide meaning of breaking centralised structure of the city of Warsaw. The proposed number of new working posts on the city edge could be an offer for surrounding existing housing dominated city districts within a short journey distance.

THE SIEKIERKI CITY IN THE PARK.

The Siekierki area of approximately 500 ha is located at the southern edge of the Warsaw Central District, 5 km from the Old Town. Siekierki City in the Park case study was developed as an entry into a series of seminars, called "Warsaw of our dreams", held in Warsaw in 2001 and described in Staniszkis (2001). Here we present the urban solutions for the central area of the whole Siekierki district. The area boundaries are clearly defined by the ecological corridors of which one is the Vistula River. Positioning in the city and unique natural landscape attractiveness of Siekierki were the reasons of designating this area in urban plans starting from early 30s of XX century for very special and distinctive urban settlement. None of this ideas materialised and still agricultural or uncultivated land remain in the central location of the city.



Figure 3. The Siekierki City in the Park 1)Vistula river 2) old river bed 3) ecological corridor 4) sewage plant 5) Siekierki bridge 6) Central Park 7) Cemetery 8) Sports Centre 9) New Old Town 10) Traditional City 11) tramway line 12) Housing areas

The contemporary chances for development of this area come up from the recently constructed new bridge across Vistula and from construction of a new sewage plant of

southern Warsaw that has began at the edge of Siekierki. The goal of the plan, as well as of the plan of Wilanów, was to preserve as much as possible of the climatic city wide role of the existing open land. That could be achieved by concentrating densely built up areas, served by the central sewage system, shaped in a form of urbanised belt between the river and the old river bed along the tramway line connecting Siekierki with other parts of the city. The rest of area remains generally open land and this way the appropriate balance between the natural and urbanised areas can be kept in a form of the City in the Park sustainable development.

The next goal of Siekierki plan is creating a traditional city-scape of streets alleys, squares, piazzas, and markets. Traditional public spaces are enabling a dense public life of various activities, which the mixed-use, densely built up area is offering in opposition to modernistic zoning and contemporary zoning of the "100-mile city" and even the previously proposed low density Park City. Problems of contemporary city public spaces are widely described by Sudjic (1993). The plan proposes built up density factor similar to that of the Central District of Warsaw of housing up to 2,5 and for commercial uses up to 4,5, which still gives the opportunity to keep 40% and 20% of biologically active area on every plot. Taking under consideration that the open green areas are within the longest walking distance of 300 meters, such living conditions meet both contemporary expectations: living in the traditional city and being close to the nature in everyday life.

Development program of this area, due to the various land uses and to the concentration of new working posts, and typical for city centre program serving not only the housing areas in vicinity of Siekierki, can be an important element in the whole city policy of deconcentrating the journey goals and diminishing traffic jams specially in rush hours.

The very important influence for the plan has the townscape identity of this specific area mainly compose of the natural landscape features as the Vistula river, and the old river bed forming a characteristic U–shape green belt. But except for those physically existing landscape elements, the urban composition is based on Warsaw urban ideas of development, which historically began with settling the compact Old Town right at the river bank. Also in modern plans the general approach to the river was to preserve its natural landscape and to develop green public spaces along the river banks. Continuity of these two contradicting ideas resulted in proposition of building the modern Old Town on the river bank as the compositional and functional culmination of the traditional, belt shaped, city and of developing in the centre of the area of the modern Central Park of Warsaw of about 70 ha size, similar to the size of the most famous historical park of Warsaw – Łazienki Park.

The Central Park can be developed in various forms according to the possibilities of the city budget, developers' offers and policy of the whole city development. The Central Park proposal is open for various great public undertakings, such as for example the Warsaw Olympic Centre or the Ecological Education Centre. Small private activities, such as sport clubs, park hotels, low density housing or business parks and city agro-touristic centres including ecological city farming can also be used to develop this area. The Central Park, in such a form of Park of Parks can start to be built from now on under constrains to keep 90% of biologically active area on every plot and building density up to 0,2. The cemetery located in a historical military fortress, as a part of the Central Park programme, is not only the proposal to complete all human needs in the city, but also, due to its exposed location, to enhance the cultural and social role of necropolis as immanent part of the living city. We believe that such an approach to location of the cemetery in the city, also proposed in the Wilanów case study, is a part of the sustainable development philosophy.

CONCLUSIONS

The presented case studies of the Park City and the City in the Park show how the new development of city districts is an opportunity, not only to create new local values for local living conditions, but also as a chance to maximum possible improvement of the whole city. If preserving and enhancing in every development the cultural heritage and natural landscape identity is the goal the local interests and the city global interest can be met in the form of sustainable city. Protecting green areas in every city must be the goal of development. This is especially important in the city, which sustainability is based on the balanced regional hierarchy between the man made and natural environments. Hence building in the green corridors within the city structure, although tempting and subject to developers' pressure to do so, is a threat that the city will convert into the urban sprawl. We believe that the only way to protect open spaces in the city is through development of these areas. There are many different ways of developing green areas and many forms of contemporary city land use meeting requirements of natural environment protection, see Staniszkis (1995). Public green spaces as well as greenery of private plots are both crucial for the city sustainability.

Every city under various local conditions can be sustainable in its own way and this is conditioned only by the consciousness that the sustainable development has no alternative for the good of the local and city-wide condition.

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Comparative Evaluation of Residential Energy Consumption between Urban and Rural Housing in Jordan

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1. INTRODUCTION

Sustainable development in Jordan is typical of many developing countries. Jordan has no significant oil resources of its own. It imports almost all of the oil it needs. In 1998 Jordan was estimated to import about 97,000 barrels of oil per day (MEMR, 1997). Jordan produces only 5 percent of its energy requirements. The local recourses are either limited oil and natural gas or undeveloped oil shade.The production is 1.4 thousand tons of oil and 10 billion cubic feet of natural gas (MEMR 1997), that is used completely in electricity production.

Because of the lack of domestic energy resources, Jordanian policy-makers are giving increasing attention to the energy sector. The Ministry of Energy and mineral resources (MEMR) expects that local demand for energy will increase by an average of 4.5 percent annually (DOS, 2002). The country's total demand for electrical power, 6123 gigawatt/hour in 2000, is expected to grow by 9.0 percent annually.

The purpose of this research paper was to examine the differences of energy demand and expenditure patterns between urban and rural areas in Jordan. More specifically, this study was concerned with the following questions: (1) Are there differences of energy consumption between urban and rural areas? (2) What are the factors affecting residential energy consumption in Jordan?

To achieve the goals of the research, between- sample variation design (urban and rural) was adopted. A T- test was developed to examine the energy consumption patterns between urban and rural areas in Jordan. Moreover, descriptive evaluation of construction systems that included building types, construction materials, areas, and age of building was done. The results of this research will be beneficial to energy policy-makers in Jordan, architects, engineers, and researchers who are concerned with residential energy consumption and its relation with construction factors. This paper is based on a survey conducted by the Jordanian Ministry of energy and Mineral resources (MEMR, 1997). They surveyed 6885 houses in Jordan in 12 major regions that include 5292 houses in urban and 1593 houses in rural areas.

2. RESIDENTIAL CONSTRUCTION SYSTEMS IN JORDAN

More than 421,670 single-family and multifamily encompass the residential sector in Jordan (DOS 2002). These include: Villa, Dar, Apartment building, Barracks, Hair Tent, and others (Figure 1). These houses are located in urban and rural areas, where the construction system is different and life style as well. Building in rural areas tends to be more sustainable and based on

traditional construction systems and local materials, such as: Mud bricks and rubble, asbestos, wood, Zink, wool hair, and others. While in metropolitan areas the construction systems tend to be developed and the building materials are: industrial materials, cut stone, concrete, and cement bricks. The following are the major construction variables that were studied in both urban and rural areas

Figure 1. Percentage of Building Types of the Residential Sector in Jordan.

Figure 2. Percentage of Construction Materials of the Residential Sector.

Dar, which is one story building, consists of number of rooms centered around a court, is considered as the highest share of building types in Jordan, it represents 63% of the whole country, 46.5% in the urban and 77.1% in the rural areas. Apartments comes in the second level and represent 31%of the entire country, it is 62% in the urban and 35%in the rural areas.

Cement brick is considered the most preferred construction material in the entire country and at the level of urban and rural regions as well. It represents 57% of the entire country and 57.8% in the urban and 56.1% of the rural areas. Mud and adobe are highly used in villages and small towns while are rarely used in big cities.

Flat roof is the most popular system in both urban and rural areas. It represents 95.2% of the whole country. Slope roof is not popular in Jordan. It represents about .2% of Jordan, and none of the survey sample has a slope roof in the rural areas.

Figure 3. Comparison of Construction Materials between Urban and Rural Areas.

Figure 4. Distribution of Housing Units in Urban and Rural Areas According to Year of Construction.

Figure 4. Distribution of the Housing Units in both Urban and Rural Areas, according to the Area of Building.

Most of the housing units were recently built, around 70% of the entire housing of the country built in the year 1970 or after. Around 78% of the dwelling built in the rural areas in the year 1970 or after while it is 65.9% in the urban areas. Area of the dwelling in both urban and rural areas is similar. More than 80% of the population in urban and rural communities live in dwelling that range from 50-200 meter square.

3. RESIDENTIAL ENERGY CONSUMPTION PATTERNS IN JORDAN

Residential sector consumes 18percent of the total energy consumption (MEMR 1997) and 33 percent of electricity energy demand (NEPCO, 2000). The annual consumption of energy used in the residential sector of the country from deferent sources of fuel is

approximately, 9000 gigawatt/hour (Akash 1999), and 1981 gigawatt/hour of electricity consumption (NEPCO, 2000). The energy sources include electricity, kerosene, natural gas, fuel oil, liquefied petroleum, wood coal, and other renewable sources such as solar energy. Households use energy to heat and cool their homes, to heat water, and for cooking and lighting.

The percentage usage of diesel fuel is 15.4% at the level of entire Jordan, the usage at the level of urban regions is 15.7% and 14.3% in the rural regions. The dwellings that use a central heating are 9.5% at the level of the country, and 11% in the urban areas and 2% in the rural areas. The use of diesel fuel for heating (other than central heating) is 8.5% at the entire level and 6.9% in urban and 13.8% in the rural areas.

Kerosene is very preferred energy source in Jordan. The percentage of buildings that use kerosene is 83.2%, 81.3% in the urban and 89.6% in rural areas. The use of kerosene is very high for the central heating. 79.1% of the household in the country use kerosene for central heating. It is 77.7% in the urban and 83% in the rural areas. The use of kerosene for water heating comes in the second level. 16.9% of the households use it for water heating. 15.2% in the urban and 22.1% in the rural areas.

The percentage usage of electricity is 99.1%. The entire urban households have electricity and 97.5% of the rural households use electricity. The bottled LPG is very popular in Jordan. 99.4% of the Jordanian households use bottled LPG. 97.4% of the dwellings use them for cooking and 28.1% of the houses use them for heating. The usage of Firewood and biomass is not common these days (not as in the past). Around 13.9% of the houses use firewood as a major energy source. 5% of these houses are in urban areas and 15.9% in the rural areas. On the other hand, the use of biomass is very limited in the whole country. 0.8% of the houses use biomass, 0.6% in the urban and 3.3% in the rural areas.

Table 1 Energy sources for different applications in urban and rural area and the percentage of households.

Energy Source□Percentage usage □□□Space Heating□Water Heating□Cooking□Lighting□□□Urban□Rural□Urban□Rural□Urban□Rural□Urban□Rural□□Diesel fuel□18.6□15.8□11.0□3.7□-□-□-□-□□Kerosene□77.7□83.7□15.3□38.9□1.3□3.2□3.9□13.1□□Bottled LPG□30.3□20.7□14.1□17.4□97.4□97.4□0.3□2.0□□Electricity□1.9□1.3□17.8□14.9□1.8□0.4□99.6□97.5□□Firewood□2.3□6.3□2.1□7.8□1.7□9.6□-□-□□Biomass□0.2□.8□2.2□2.9□1.1□2.0□-□-□□Solar system□-□-□27.0□17.9□-□-□-□-□□

Table 2 Evaluation (T-test) for energy consumption in urban and rural areas

T-test□□Group		*N*	*Missing*
Urban	5292	0	
Rural	1593	0	
Group	*Mean*	*Std Dev*	*SEM*
Urban	207.6	188.3	2.59
Rural	195.1	134.9	3.38

Difference 12.5

t = 2.47 with 6883.0 degrees of freedom. (P = 0.0134)

95 percent confidence interval for difference of means: 2.60 to 22.5□□

As shown in table 2, a T-test was conducted to test the main null hypotheses of the research that states: there is a significant difference between the two groups, urban and rural. The t-value is 2.47 and the p-value is 0.0135 which is less than 0.05. That means the difference in the mean values of the two groups is greater than would be expected by chance; there is a statistically significant difference between the input groups (P = 0.0134).

4. DISCUSSION AND CONCLUSIONS

Sustainable construction aim to lessen their impact on our environment through energy and resource efficiency. Therefore, the rational use of natural resources and appropriate management of building stock will contribute to saving scarce resources, reduced energy consumption and improving environmental quality.

Rural areas in Jordan have been and continue to be a vital part of the country. They comprise 83percent of the entire area of Jordan and they house 30 percent of the people. The typical rural community consists of small towns and villages with numerous small farms. In the past, most of the people were living to fulfill most of their needs, economic and otherwise within their community. They had little contact with areas beyond the community.

There has been a great change in the rural areas in many ways over the last three decades. The rural community has changed shifting from dependence on farming to a prominent diversity of economic activity. Moreover, the connection between rural areas and cities considered as significant change. The improvements in communications and transportation between the two have reduced rural isolation and removed many of the cultural differences between them.

Residential construction systems in Jordan have changed through the last three decades. Most of the housing units are recently built, around 70% of the entire housing of the country built in the year 1970 or after. Around 78% of the dwelling built in the rural areas in the year 1970 or after, while it is 65.9% in the urban areas. This indicates that there is enormous development in the whole country during the last thirty years, and there is a drastic change in economic and lifestyle that result to construct a new housing. Dar is the proper prototype for the whole Jordanian. However, the rural Jordanians prefer DAR more than the urban. This is because it is suitable to their country activities. On the other hand, apartments are very popular in the urban and rare in the bucolic areas.

The overall energy consumption in the urban regions is about 84 percent of the whole country (Akash, 1999) and 16 percent in the rural areas. This indicates that most the Jordan society is urban (Akash, 1999). Electricity is used in both regions mainly for lighting and running electric appliances. Bottled LPG is major source of energy and is used for space heating and cooking. In cities they used bottled LPG for heating while in villages they preferred to use kerosene because it is inexpensive and easily found. Firewood and biomass is widely used by rural communities (Akash 1999). This is because of its availability and the life style of rural regions.

There are three factors have an effect on energy consumption patterns in residential buildings, these are: climatic factors, construction factors, and behavioral factors (Goldstein, 1985). Distribution of housing units in Jordan both urban and rural areas is not associated with climatic conditions. Therefore, climatic factors are not foremost to differentiate energy consumption

patterns between urban and rural areas in Jordan. On the other hand, construction factors play a significant role on the efficiency of buildings. Building envelope, which consists of walls, windows, doors, roof and floor, is the main determinant of building performance and major factor that explains the variability in energy expenditure patterns between urban and rural areas. The thermal properties of the envelope and building configurations in rural areas are helping in improving the efficiency of buildings. Finally, the socio-economic status and the life style play a significant role in energy consumption. Energy consumption patterns in cities are different than villages, this is because the expenditure behavior is different and the lifestyle as well.

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Ecological housing and it's effect on inhabitants' behaviour and attitudes
The case of Torvetua in Bergen, Norway

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1. INTRODUCTION

In 1998 an area of 34 one- and two-family houses were built outside the city of Bergen, Norway. The area called Torvetua, was planned with the idea to create residential solutions that both inspire to and even creates an obligation towards a "green" lifestyle with reduced consumption and pollution. The main ecological elements in Torvetua are the following:

- *Preservation of existing vegetation and landscape*
- *Cycle based sewage purification plant (e.g. treatment of wastewater by soil infiltration)*
- *Use of healthy and environmentally friendly building materials (e.g. heartwood outdoor cladding with no need for surface treatment)*
- *Car-free neighbourhoods (common parking areas in the outskirts of the housing area)*
- *Source segregation and composting of household waste*





Figures 1 and 2: Photos showing how the houses in Torvetua are subordinated to the natural surroundings (left) and also how some of the inhabitants follow up this principle in the design of their own front gardens. Photos taken October 1998 (left) and November 2001 (right)

Torvetua is designed by Architect Bjørn Eik who was one of the iniators together with a highly profiled environmental activist in Bergen, Kurt Oddekalv. The developer was Block Watne house factory. They were committed to realise the goals formulated by the initiators through an agreement made with Oddekalv in 1996.

2. RESEARCH QUESTIONS AND METHODOLOGY

The Torvetua study is part of a larger research project dealing with building process and housing quality. The project is funded by the Norwegian State Housing Bank. Since the main ambition for Torvetua was linked to environmental aspects, the focus of the evaluation of this

specific area has been to study to what degree the developers seems to have reached this goal and to point to the factors that has influenced the result.

Neither the research project nor this paper aim to discuss the goals or the quantifiable effects of the ecological solutions in Torvetua when it comes to their impacts on the environment. The paper will mainly deal with the following question: *How have the environmental goals affected the experienced housing quality and the inhabitants' attitudes and behaviour towards the environmental aspects?*

As a part of this study SINTEF has interviewed central actors in the development process of Torvetua: The initiators, the developer and representatives from planning authorities. Still the most important source of knowledge has been the houseowners, and this paper is mainly based on data from them. We have carried out a survey among all households and eight qualitative interviews with a selection of the inhabitants.

A questionnaire was sent to all 34 households in January 2002, and we received 21 answers (63 %). Due to the small number of participants, we are not able to draw any general conclusions from this. Still it gives an adequate picture of certain characteristics of the inhabitants in this specific area and their attitudes and opinions towards some questions. The interviews open up for an even more comprehensive understanding that will contribute to a general discussion of the effects of ecological housing.

3. COMPOSITION OF INHABITANTS AND THEIR GENERAL OPINIONS OF THE AREA

The survey shows a rather homogeneous household composition. Two thirds of the households are families with two parents and 1-3 children. There are also a few single parent families. The rest are single people and couples without children. There are very few old people and also few teenagers and people in their twenties. The majority of the adults are between 30 and early 40s and most children are under school age.

The house in Torvetua was not their first privately owned home, but can be seen as a step further in a housing career from an apartment close to the city centre. Most households had two incomes and relatively strong economy. Still a great variation of occupations is represented in the area. We find academics, artists, craftsmen and workers here.

There were three main reasons for why people chose to buy a house in Torvetua: Appealing architectural design, appropriateness for children and environmentally friendly housing. Ten among the twenty-one households answered that the last mentioned aspect was one of the main reasons for choosing this area. Many also emphasized the beauty of the natural surroundings.

The survey showed that the inhabitants in general were very pleased with the qualities of the area. The following qualities got the highest score: Enjoyable social life, closeness to natural green surroundings, high aesthetic quality of the neighborhood and attractive treatment of existing vegetation and landscape. Many were also satisfied with the architectural design of the houses both aesthetic and functional, and the common outdoor areas.

On the other side, very few were satisfied with the visual protection of private outdoor areas, the price of the houses, the technical standard, the closeness to service and public transport and the possibilities to expand their houses.

4. ATTITUDES TOWARDS ECOLOGICAL ASPECTS

Even though the household composition in Torvetua is rather homogenous, we found diverse attitudes towards the environmental topics. According to these attitudes, we can divide the inhabitants in three groups: The *idealists*, the *pragmatists* and the *sceptics*.

The idealists have a high degree of consciousness and awareness of environmental problems in general, and they had so before moving into Torvetua. They identify themselves with the ecological intentions for the area. They have gained more knowledge and practical experience after living here for some years, but have not changed their fundamental attitudes significantly. The symbolic values connected with these ideas are combined with more rational motifs. The idealists enjoy knowing that their house is built of healthy materials more than they actually experience the consequences. Some of them complain about "the others" that are not as conscious about the environment as they should be. Representatives from this group participate actively in the house owner organisation and in the social life in the area. They play a central role in shaping the future image of the neighbourhood

The pragmatists chose the house for functional and aesthetical reasons and were not more than average interested in environmental questions when moving to the area. They question the effect of the unique solutions in the area, and do not accept the ones they don't understand rationally. For example they don't understand why it should not be possible to drive to their own door if it doesn't disturb anyone. They focus on how the environmental elements affect their requirements and needs and are not willing to pay extra for some of it either in money or efforts. After living in Torvetua for some years they have gained a more positive attitude towards environmental aspects and agree that they have positive effects on the general housing quality of the area.

The sceptics entered Torvetua more or less by accident and they are generally negative to several characteristics of the area. They would have preferred an "ordinary" detached house with a larger private garden, their own garage and a more central location. The sceptics do not identify with the environmental goals of Torvetua. On the contrary, they feel that some of these aspects (especially the water and sewage system) are annoying and have reduced the quality of living in the area. Socially these people do not feel included because they do not belong to the group of "environment-conscious" people that they believe dominate the neighborhood. At the same time they are sceptical to the legitimacy of calling Torvetua an ecological area at all (mostly based on the fact that the water and sewage system does not function).

At the time being it seems that the last group is a rather small one. As many as eighteen of the twenty-one households answered that they regard the ecological elements in the area have had a positive influence of how they experience the quality of the area. They focus the *preservation of existing vegetation and landscape* and *the use of healthy and environmentally friendly building materials.* But many of them also regard the aesthetical qualities of the area as an important part of the environmental value.

4.1 Preservation of existing vegetation and landscape

"I am glad they have taken care of the nature around here. It looks like the houses are just dropped down from the sky and into a great forest" (woman, 32).

There is a general agreement among the inhabitants in Torvetua that the natural surroundings both within and out side the neighborhood is one of it's greatest qualities. Still we were told that someone did cut down some trees to get a better view towards the small lake, but this was not regarded as acceptable according to neither the regulations for the area nor the common opinion among the neighbors.

4.2 Healthy and environmental friendly building materials

Fifteen of the households answered that this aspect is of great importance, but only eight thought it was satisfactory in Torvetua. The intention was to create "breathing" houses with cellulose filament as insulation, no PVC in electric wires, heartwood outdoor cladding with no need for surface treatment and turfed roof which in principle should be self-maintaining. It was also advised from the initiators that the indoor surface treatment should be done by environmental friendly (non-toxic) products.

When it comes to the surface treatments – both outdoor and indoor – many house owners have chosen traditional methods. This is due both to general scepticism towards the advice from Oddekalv, partly to aesthetic considerations (they don't want a grey house), and partly due to a lack of knowledge, consciousness and interest. It was also strongly advised not to use pressure-impregnated materials in outdoor terraces. This has obviously been a topic of debates in the area. The most environment-conscious inhabitants thinks it is a shame that some of their neighbours don't take this advice seriously and try to persuade them to do so.

For the ones who have tried to do it all the "right" way, it gives a great satisfaction to know that they live in a healthy house. Even though some of them have experienced a better indoor climate then they had in earlier homes, the quality for most of them seems to be just as much a symbolic one as one based on rational facts and knowledge about the materials.

4.3 Cycle based sewage purification plant

When it comes to the *cycle based sewage purification plant* (which also includes a vacuum toilet system) there had been several technical problems, and from the survey it seems that none of the inhabitants were satisfied with this solution. Still the interviews gave a more differentiated impression of the attitudes. The board of house owner organization in Torvetua had worked hard to secure that the system functions satisfactory. They have established a "technical group" among the inhabitants who are responsible for solving problems when they arise. Most informants made it clear that the problems are diminishing, and that the system now seems to function quite well. Still many of them questioned if this really is a very ecological system as long as the sewage is not composted to manure for use in the farming industry (which was a part of the concept from the beginning). Instead it is collected by the municipality and dumped together with other sewage. Many had also been disturbed by unpleasant odors from the sewage pump house, and remark that this is not particularly environmentally friendly.

On the other hand, some informants pointed out that problems like this had led to a kind of team spirit within the neighborhood which was both constructive and encouraging and had a positive effect on the social life.

4.4 Car-free neighbourhood

When it comes to the intention to create Torvetua as a car-free neighbourhood, this has shown to be perhaps one of the most controversial topics. Informants told us that the area seems to be divided in two camps on this point. Half of the inhabitants wish to drive all the way to their houses and preferably to park just outside the entrance door. They do not see car driving in

the area as a problem either against the safety of children (because they all drive very careful) nor against the ecological image of the neighbourhood. Even though it might not be a definite coherence between carfreeness and ecological qualities, this was emphasised by the initiators of Torvetua. For many of the inhabitants who want to keep the cars out, the emotional attitudes towards the car seems to be more important than the more rational (e.g connected to safety and pollution). They don't "like" to have the cars around the houses. Still very few of them question the fact that most households depend on private cars to get to work, go shopping, deliver children leisure activities etc. Many households have two cars. Even if they are critical to the inadequate collective transport, this seems to be more of a practical problem than an environmental one.

4.5 Source segregation and composting of household waste

It is not a collective system for source segregation and composting of household waste in Torvetua. Nearly half of the households point this out to be weakness that should have been taken better care of. Some informants think that the municipality should take a responsibility for this and that the developers could have made agreements on this in an early stage of the project. Other feels that this should be a common task for the neighbourhood, and others again think that this is a private matter.

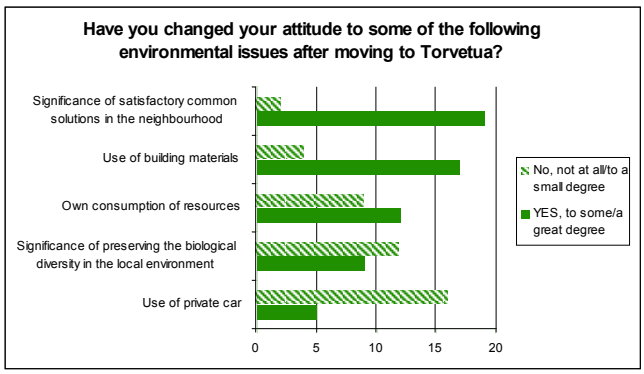
4.6 Other relevant ecological aspects

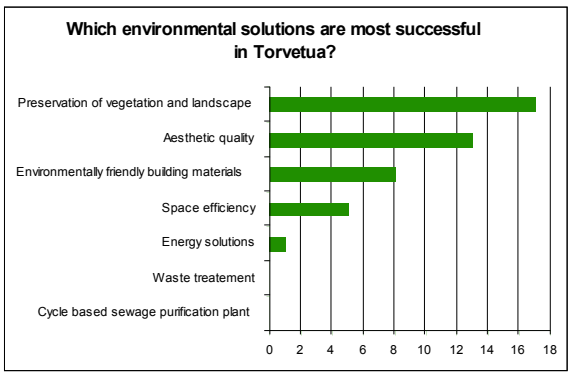
In the survey we asked the households to indicate which ecological issues they believe should have been accomplished to a greater degree in Torvetua. Sixteen households answered that there should have been more use of new renewable energy sources like heat pumps, solar energy etc. Nine households indicated that they miss adequate control and feedback systems for energy use. As mentioned earlier, also a better system for source segregation and composting of household waste had a high score.

When it comes to other aspects focused in the general discussion about sustainable housing such as more compact housing and central location (due to energy use for heating and transport and use of land), this does not seem to be topics of discussion among the inhabitants. On the contrary there are several informants who find the lack of opportunity to expand the living space as a weakness. And they only to a small degree question their dependency on private cars for transport.

5. CHANGES OF ATTITUDES AND BEHAVIOUR

Torvetua was marketed and sold by Block Watne as quite ordinary houses and the ecological aspects were de-emphasised in this process. However there is a belief among the initiators of the area, that even if there were quite ordinary people moving into this area, many of the inhabitants have changed their attitudes and behaviour after living a few years in Torvetua: *"They have started to think like a village!"*





Figures 3 and 4: To the left we see to what degree inhabitants have changed attitudes to environmental issues. The figure to the right shows which solution they regard as most successful (each respondent could mark three issues). Both figures show results in number of respondents.

The survey supports this assumption. Many inhabitants answer that they have changed their attitudes after moving to Torvetua. In particular they have become more conscious of the significance of establishing satisfactory common solutions, of the use of building materials and of their own consumption of resources.

There are several reasons for the changes in attitudes and also in behaviour. The physical solutions are clearly a part of this, since they in some ways more or less force their users to certain behaviour. For instance they all had to learn how to use the vacuum toilet system to prevent technical problems. But as one informant said: *"The area is not necessarily ecological now that it is inhabited. It is people who make it ecological. It doesn't become more ecological than what you make out of it"* (woman, 31)

The social structure of the area is of high importance. Discussions among the inhabitants clearly influence both attitudes and behaviour. There seems to be a kind of social pressure from the dominating group within the neighbourhood. The board of the house owners' organisation consists of strong-minded and conscious people who see it as their responsibility to make other inhabitants to commit themselves stronger to the intentions of the area. Thus the topics they and other "idealists" tend to discuss are closely connected to the ones put on the agenda by the initiators and thus materialised in the physical structure of the area.

6. CONCLUSION

The study shows that the environmental qualities of Torvetua were important reasons for why people chose to buy a house there. These elements have also contributed strongly to the experienced housing qualities. The environmental aspects most widely accepted are the ones with the highest symbolic values: Preservation of existing vegetation and landscape, use of ecological building materials and also aesthetic expression. The aspects creating most inconveniences (practical and economic) meet a greater degree of scepticism. Many inhabitants question the actual ecological effects of these efforts, and only the most idealistic are supportive. The study also shows that the process of living in Torvetua creates higher consciousness among inhabitants and it influences their attitudes towards the environmental qualities emphasised in the area. Issues put on the agenda by the initiators of the area influence the attitudes of inhabitants to a greater degree than topics that are central in the general discussion of sustainable development (e.g. energy and space efficiency and reduced use of private cars).

Norwegian building energy statistics; specific energy consumption and consumption by category of use

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1. BACKGROUND

In 1996 the Norwegian Energy Administration (NVE) decided to establish (Enova SF in 2002) an operating apparatus which was given responsibility for the implementation of the Norwegian State's energy conservation programme. On the building side, NVE's Building Operator (who is now Enova's Building Operator) was given responsibility for developing a network of building owners whose reports of energy consumption would form the basis of a set of national statistics for building energy consumption by category of use.

In 2002, the total measured area of Norwegian buildings adds up to around 330 million square metres, of which about 120 million m^2 consist of commercial/industrial buildings. The remainder is housing, of which housing cooperatives account for some 30 million m^2.

Norwegian buildings consume a total of about 80 TWh of electricity a year, of which non-residential buildings use about 34 TWh. Figure 1.1 shows that about 32.5 TWh of electricity are used for heating purposes every year. The reason for this is that Norway has had easily available hydropower for many decades. Hydropower development has now come to an end, and with the continuing rapid growth in building energy consumption, in a typical year Norway now needs to import a considerable amount of electricity from its neighbours.

This is the main reason for the decision of the Storting in 2001 to set up a new state-owned company known as Enova, which has been given a ten-year mandate to restructure the national energy use in terms of conservation, conversion to other energy carriers and energy generation from new sources.

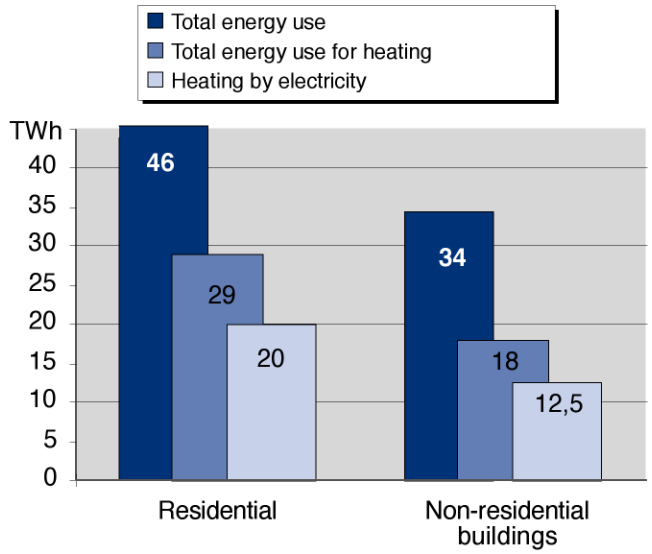

Figure 1.1 Energy consumption in Norwegian buildings in 2000

2. THE BUILDING NETWORK - CONTENT, SCOPE AND RESULTS

Since 1996, a network has been built up of building owners who must agree to reduce their energy consumption by supporting a range of activities in a network process. The network process lasts for between two and two-and-a-half years, and the building owners must commit themselves to cutting energy consumption by at least 10%. Financial support is not provided for investments, but for activities that raise awareness of energy consumption at all levels of the company. Typical activities include energy management, energy-use planning, energy follow-up and analyses, training and consumer information.

The Building Network currently consists of some 350 building owners who have supplied information on about 2000 buildings to the central database maintained by Statistics Norway.

About 80% of the buildings are in the public sector, while the remainder are privately owned. From 1996 until 1999 public-sector buildings were given funding priority.

Every year, about MNOK 18 has been distributed to network projects, which have produced annual savings of about 100 GWh, totalling about 600 GWh over the six years of the project so far. When the administrative costs of the Building Network are included, funding comes to around NOK 0.20 per kWh saved energy.

Since 2000, all buildings that join the Building Network have had their energy consumption measured before and after the network process. Starting in 2002, incentive agreements have been set up in order to relate the payment of support funds to the achievement of specific targets.

3. ENERGY STATISTICS FOR INDIVIDUAL BUILDING CATEGORIES

3.1 Energy statistics - basis, scope and utilisation

The establishment of the Building Network made it possible to develop a set of building energy statistics. Building owners who become members of the Building Network agree to report the energy consumption of a range of buildings for five years. Statistics Norway performs the statistical analyses and maintains the database of buildings. Statistics Norway's database contains basic data energy data on all the buildings, recorded on a standard template.

Since the sample of buildings is not random the figures that emerge from the statistics cannot simply be extrapolated to the total Norwegian building mass. For the categories that include the largest number of individual buildings the average figures are more representative than for the other categories.

In 2000, the statistics were based on data from 1039 buildings all over Norway, and in 2001 this figure had risen to about 1350 (the statistical report for 2001 will be published in June 2002).

As well as energy consumption, the report includes statistics on energy carriers, heating systems, ventilation systems and indices of use.

The statistics are based on the following criteria:

- Energy consumption is measured as gross metered energy

- Area is measured as heated area according to Norwegian Standard (NS) 3940
- Building categories are defined according to NS 3457
- Climatic corrections are applied with respect to a normal year, but no corrections are applied for geographical location (climatic zones)

These statistics have become an essential tool for many actors in the building industry as well as for the authorities:

- Building owners use them in benchmarking their buildings vis-à-vis other building owners and buildings, and when estimating the energy consumption of new buildings
- Technical consultants use them in planning new buildings and conversions
- Energy companies use the statistics when making estimates of the power requirements of new installations, etc.
- For the authorities the statistics form part of the basis of the ongoing process of evaluation of the general energy situation.

In order to ensure that the statistics are as good as possible the Regional Energy Efficiency Centres network has been engaged to quality-assure the energy reports before these are sent over to Statistics Norway via the Internet.

The report, which is published and distributed throughout the sector, is processed by Enova's Building Operator. All the building owners who have submitted reports of energy consumption also receive data on their own buildings together with comparison data on other buildings of similar type, presented as shown in Figure 3.2.

3.2 Energy statistics - content and analyses

The statistics for 2000, which were published in mid-June 2001, referred to 1039 buildings with a total area of 5.8 mill m^2. Their total annual energy consumption was about 1.4 TWh, or 248 kWh/m^2.

Figure 3.1, the main diagram obtained from the statistics for 2000, shows energy consumption for individual building categories by energy bearer. We can see that commercial buildings have by far the highest energy consumption, while schools have the lowest consumption of non-domestic buildings. In 718 of these buildings, which had reported information in both 1999 and 2000, total temperature-corrected energy consumption fell by 3.8% from 1999 to 2000.

Figure 3.2 illustrates two examples of how energy consumption varies within a single building category. In 143 office buildings, energy consumption ranged from 90 to 520 kWh/m^2. Similar large variations were noted in school buildings. We can see that for schools with swimming pools, mean energy consumption increased from 191 to 254 kWh/m^2.

Since the type of heating system utilised was also registered as part of the basic data, it was possible to analyse how energy consumption varied according to type of heating system installed. Central heating systems were installed in 60% of the buildings, representing 77% of the total heated area.

Figure 3.3 shows that for the sample as a whole, there was a difference of about 11% between buildings with direct electrical heating and those with central heating systems.

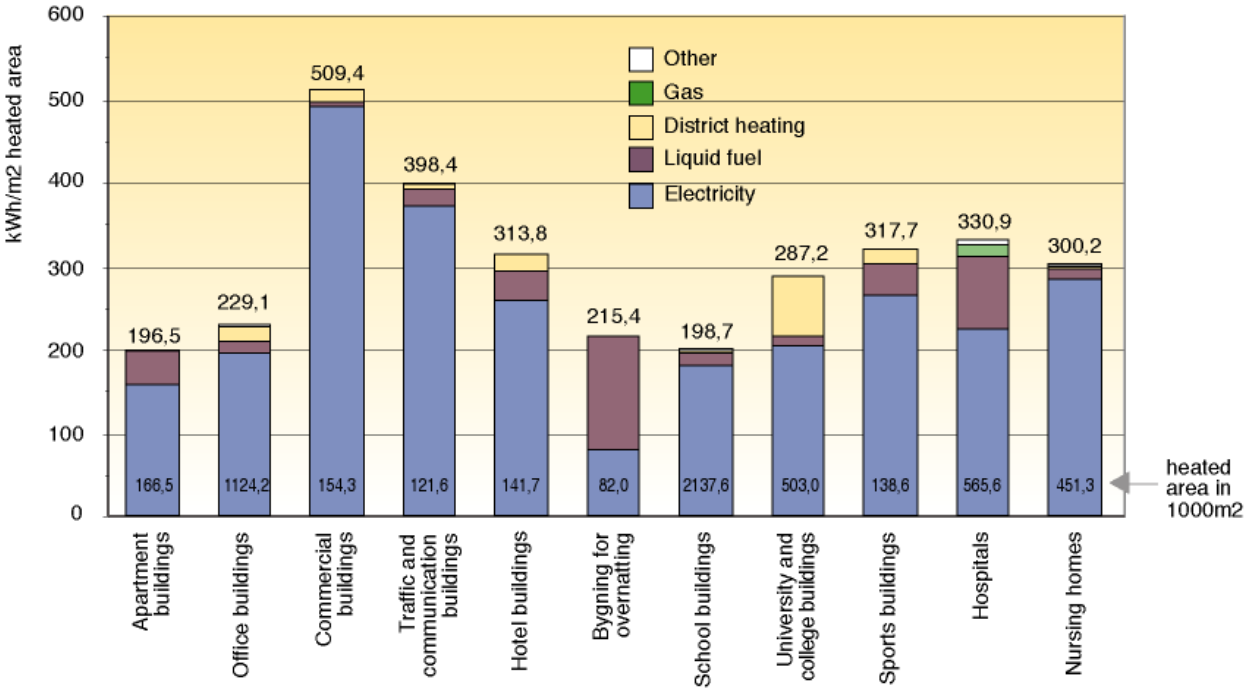

Figure 3.1: Average specific temperature-corrected energy consumption in 2000 for major building categories

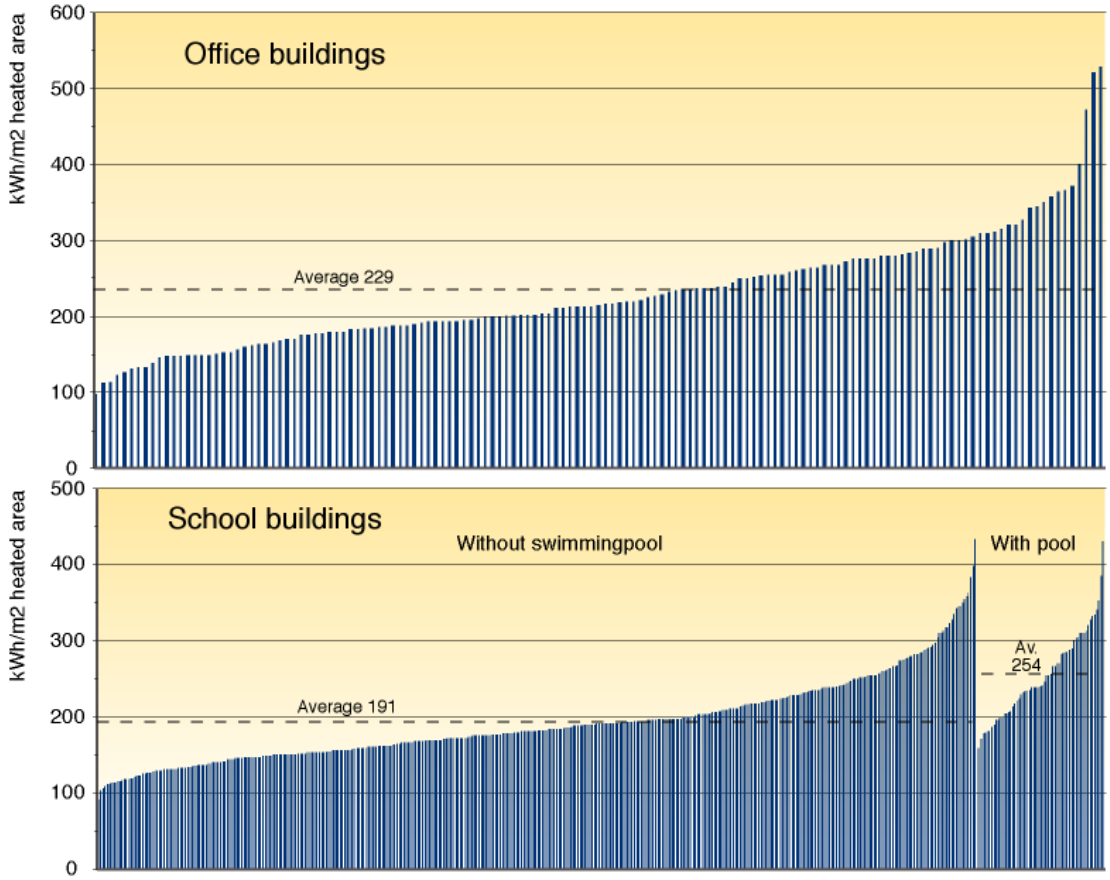

Figure 3.2: Differences in energy consumption in individual buildings in same category of use

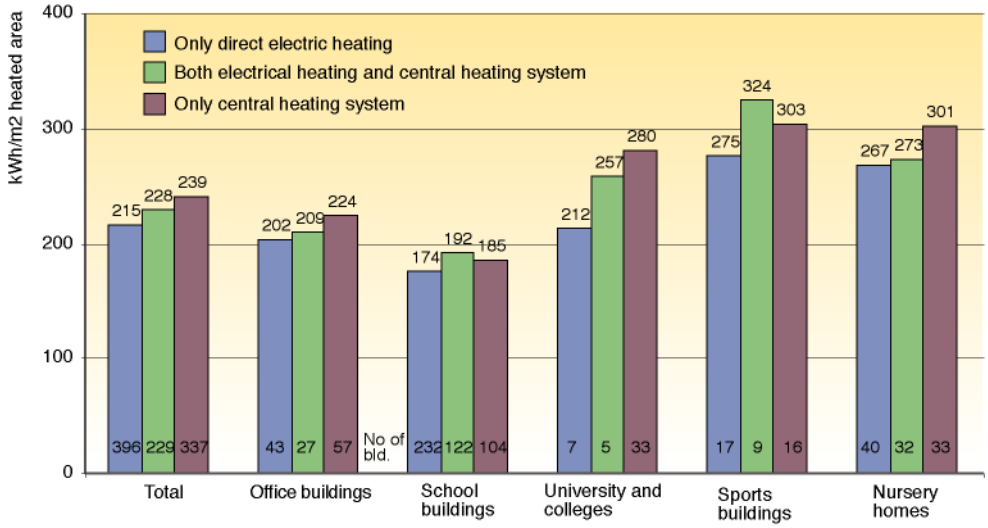

Figure 3.3: Energy consumption in buildings with different types of heating system

82% of the buildings had balanced ventilation installed, 65% of these as the only system. 83% of this volume of air passes through a heat recovery unit. Comfort cooling is installed in 202 buildings; 37% of the total area.

Hours of use can be of great importance for energy consumption. Figure 3.5 shows the time of use for the most common types of building - i.e. the time that the building is generally in use. We can see from the figure that schools have the shortest average time at 10.2 hours per working day, while university building are in use for 12.8 hours a day. The long time of use for hotels and health sector buildings goes a long way to explaining their high specific energy consumption.

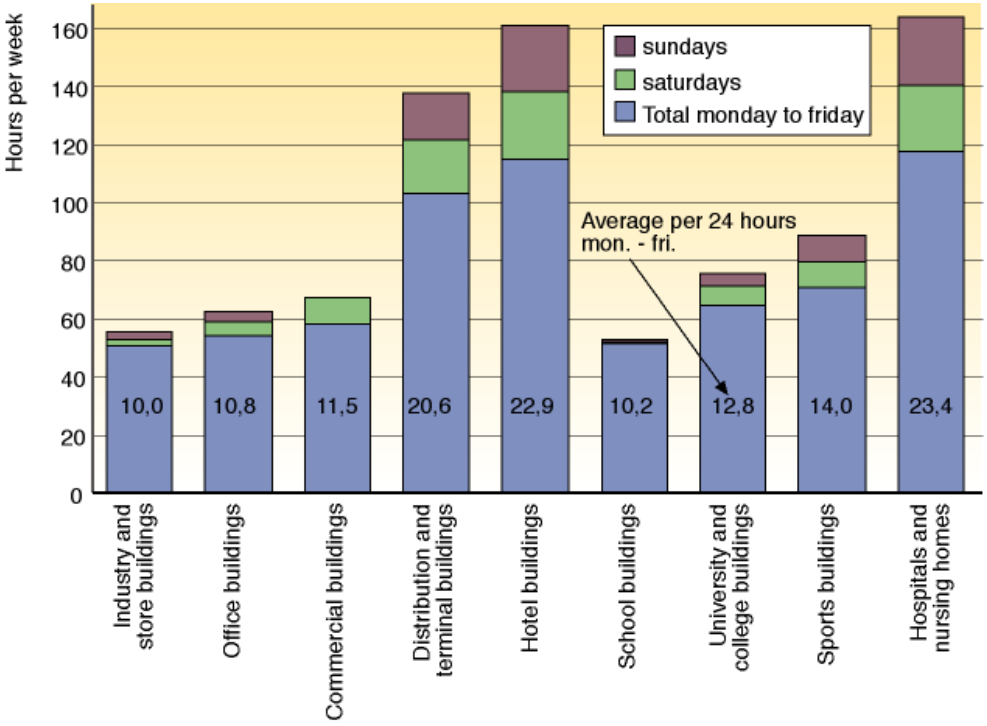

Figure 3.5: Mean total hours in use per week for the most common types of building.

4. MODEL BUILDINGS - ENERGY CONSUMPTION BY CATEGORY OF USE IN 26 BUILDINGS

In order to obtain a better understanding of the energy consumption of buildings in terms of category of energy use, such as heating, ventilation, lighting, etc., Enova carried out a project entitled Model Building. Twenty-six buildings in four categories of use were instrumented according to a common plan. The measurement programme lasted for a year, from November 2000 until October 2001.

The types of energy use were defined in accordance with NS 3031:

1. Heating
2. Ventilation
3. Hot water
4. Fans/pumps
5. Lighting
6. Electrical equipment
7. Air conditioning

For the first time in Norway a systematic study and set of measurements have been made of how energy is used in such a large number of non-domestic buildings. Even though the sample was small (26 buildings) the analyses show a number of interesting features. The general impression was that the actual uses of energy are reasonably similar to those used by the most often used estimation programmes. However, wide variations from one building to another within the same building category were observed. This implies that standard normalised figures for energy consumption by category of use must be used with great caution. This may mean that operating conditions and user behaviour have more influence on energy consumption than we have believed.

In certain areas and in certain types of buildings there are clear deviations from the norm:

- In university, college and office buildings fans and pumps are responsible for a larger proportion of energy use than was previously assumed (figure 4.1)
- In nursing homes more energy is used for lighting than previously assumed
- In most categories of building the proportion of energy that goes to ventilation and heating water is somewhat less than the estimation model suggests
- The part of energy consumption that is flexible (heating, domestic hot water supply, ventilation heat) varies more widely than expected, but for important categories such as office buildings and schools the average figures conform to expectations (figure 4.2)

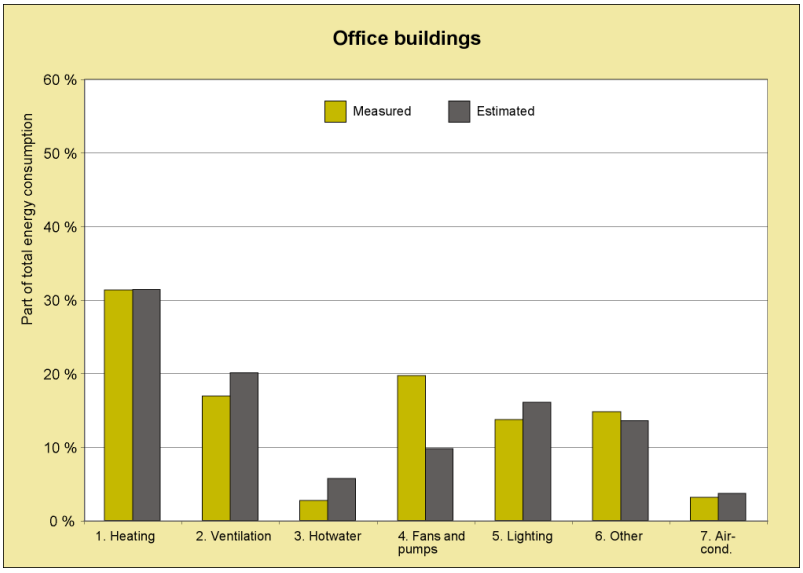

Figure 4.1: Measured and estimated figures for energy consumption in office buildings

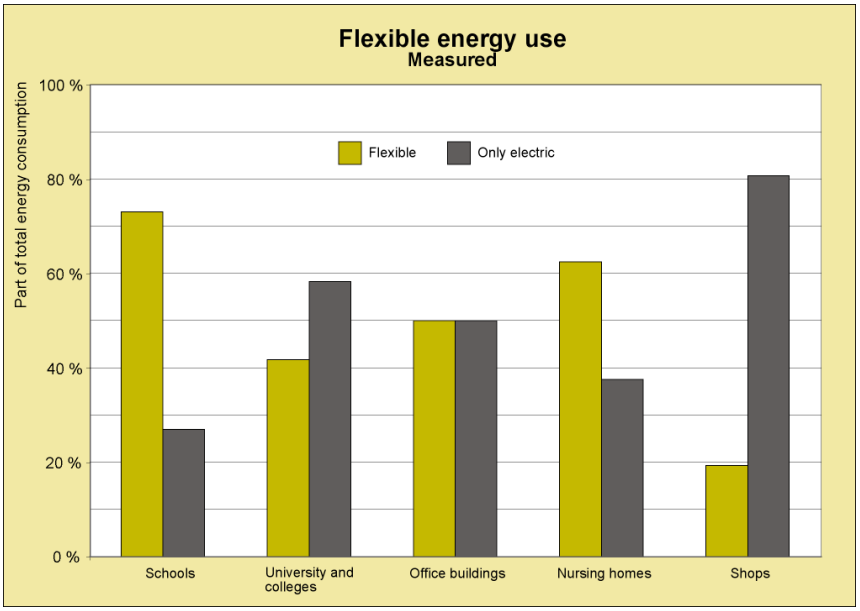

Figure 4.2 Flexible and specific proportions of energy consumption for the five building categories represented in the study

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Implementing sustainable urban standards in Wroclaw. "Green Islands" Programme

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1. CITY OF WROCLAW APPROACHES TO SUSTAINABLE DEVELOPMENT

To begin the presentation of three case studies co-ordinated by the Department of Sustainable Development TU Wroclaw, we have to define the key terms and concepts used in this paper:

A. To green means to make sustainable.
B. Implementing green urban standards shall be understood as improving the quality of life and achieving environmental and economic sustainability in selected "islands" or "poles" of growth, which could be recognised as models for other sections of the town.
C. While traditional spatial management plans following guidelines specified by local authorities are usually quite formal and static, the presented green plans are flexible, eco-oriented strategies, encouraging a co-operative relationship between city administration and the other actors on the city stage, such as the industry, NGOs, community groups and the citizens themselves. [Green Plans for a Sustainable Future. 2001.]

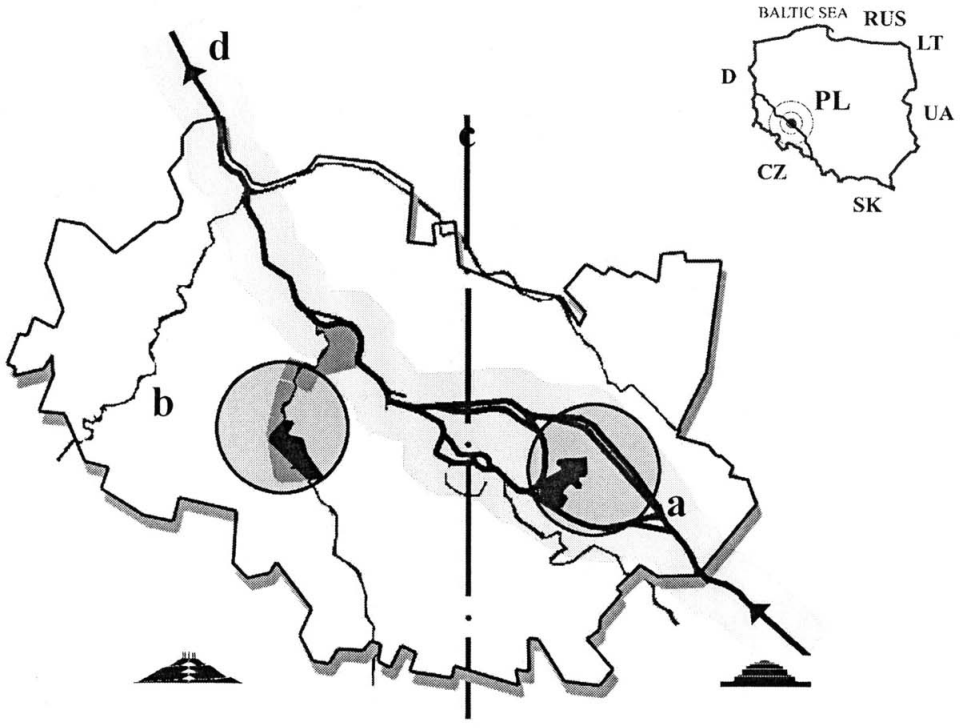

Figure 1 Two "green poles of growth" in Wroclaw: a) eastern pole: Great Island with Szczytnicki Park; b) western pole: Sleza river green corridor with the Millennium Park; c) an axis of balance; d) main recreational link along the Odra waterway.

The green plans for cities are almost unknown in Poland although some so called "ecological policies" have been articulated by local authorities since 1991, when the first "National Ecological Policy" was decreed. The policies define principal environmental objectives but usually they are not addressed to existing groups of interest. In this context, the approaches undertaken by the municipality of Wroclaw are pioneering and meaningful on the national level.

In 1994, during the Polish-Dutch architectural workshop, the "green poles" conception was formulated by the team from the Department of Sustainable Development (DSD). Likewise in yin-yang diagram, the two opposite poles of recreational functions were designated on the opposite sides of the symbolic axis of balance, passing through the historic city centre.

The first one was situated within the historic part of the city, in the belt of green suburbs; the other was located on the fringe of new housing estates. Connected by the waterway and Odra river biological corridor (harmony line in yin-yang diagram), the poles could generate the tourist movement along the river. In response to the social needs, the green areas should be appropriately adapted (on the eastern side) or created (on the western side), considering the local climate and other environmental factors (Figure 1).

Although the "green poles" conception has not yet influenced the spatial management plans for the city, it has stimulated the research activity of DSD. As a result of the recent co-operation between the city administration and the Technical University of Wroclaw, three case studies demonstrate the green plans' assumptions for the mentioned poles and their links.

2. CASE STUDIES

2.1. Case Study 1: "Green Islands" Research Programme

In 1997, the citizens and the city council decided to establish an individual form of landscape protection over two islands, situated in the eastern side of the Odra river valley. They both have been created as a consequence of regulation works in the first decades of the 20th century and together cover an area of 11 square kilometres, representing the unique natural and historical resources. Members of DSD took part in defining the scientific foundations of the resolution and in 2001 initiated the Green Islands research programme, financed by the National Committee for Scientific Research and the City of Wrocław. Drapella-Hermansdorfer et. al. (1996).

2.1.1."Green" Standards – Learning from the Past. Together with the adjacent Zoological Garden and Botanical Study Garden, the historical Szczytnicki Park, located in the centre of the bigger of the two islands, the so-called Great Island, creates an exceptional green enclave, with many rare species of trees. An added attraction are the structures erected for the 1913 Centennial Exhibition, with the famous Centennial Hall by Max Berg (now – the People's Hall – main landmark of Great Island). This diversified area links diagonally to so called Olympic sport grounds, and – from the other sides – adjoins to four green suburbs from the 1920s and 1930s. The whole complex, surrounded by the green belt of biological river corridors, promenades and waterways sets the model example of harmony and high living standards of the cityscape. Moreover, each settlement can be recognised as a model housing unit, typical of the period of its construction (Figure 2).

2.1.2. Vision of Sustainable Urban District. The mentioned values have generated the rise of investment activities, especially during the recent decade, but the new functions rarely correspond with the surroundings. For this reason, the economic initiatives should be stimulated towards more desirable objectives, promoted by the Green Islands (GI) programme.

Despite the unique landscape and cultural values, the network of tourist and recreation services within the area is poorly developed. On summer Sundays from 5-10 thousand persons visit the Zoo while cultural and sports events in People's Hall or Olympic Stadium also attract thousands of spectators. In addition, every weekend a boat cruises from Berlin and the area of the historical Wilhelm's harbour seems the best place to start a tour of the city. In response to these needs, the GI pilot project demonstrates a model green urban district which has been also envisioned as a multifunctional tourist centre. The authors set out a series of steps to establish Citizen Steering Committee in order to direct the decision-making process.

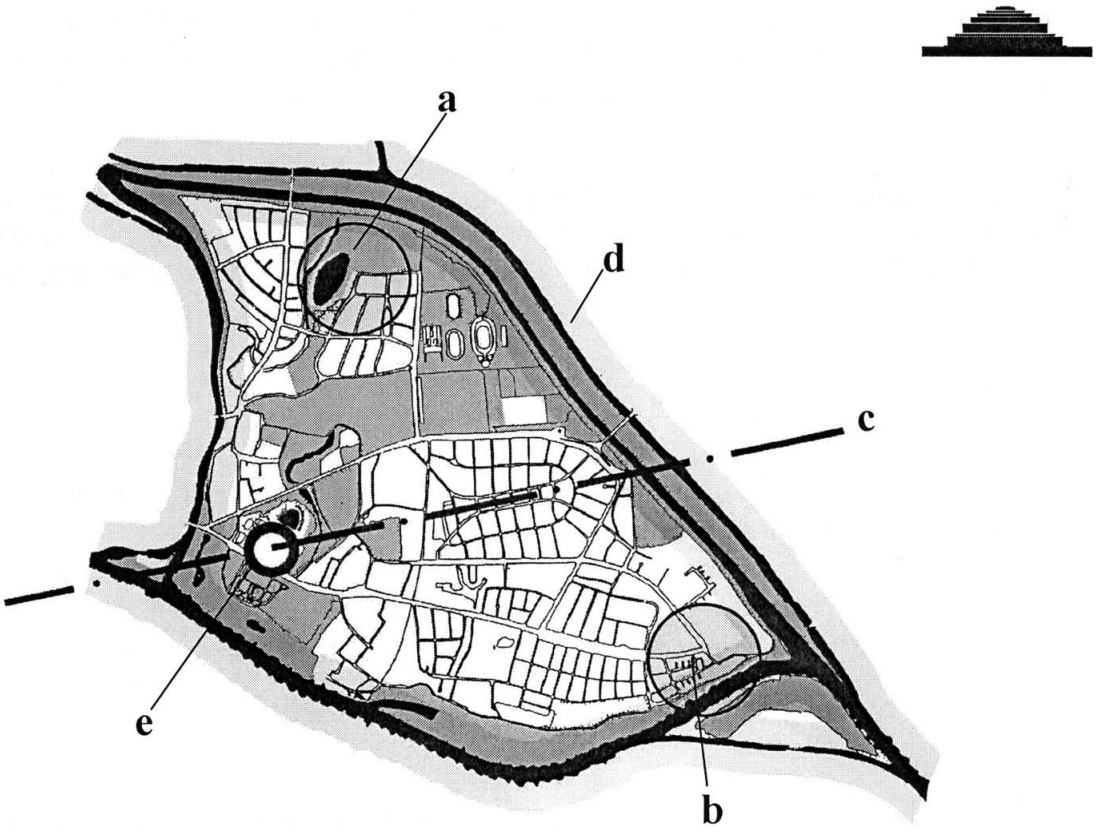

Figure 2 The "green poles" of recreational activities within the Green Islands zone of protected landscape: a) the north pole: The " Eye of the Sea" swimming pool with the adjacent park and recreational facilities, b) the south pole: new hotel and camping area nearby the historical harbour; c) axis of balance; d) main spatial links along the river branches and channels, e) the People's Hall – main landmark of the area.

2.2. Case Study 2: The Millennium Park Project

Contrary to the existing Green Islands' recreational grounds, the western pole would be developed step by step as a constellation of parks and exhibition areas, planned along the Sleza river. The Millennium Park plays a key role in this future complex. Located on the

outskirts of big housing estates and adjoining the area reserved for EXPO 2010, for which the city is competing, the Millennium Park has been conceived as a counterpart to the Szczytnicki Park in the eastern part of the city. Drapella-Hermansdorfer (2001)

2.2.1. Seeking the Balanced Urban Structures. In fact, Wrocław has no grounds to serve the modern recreational needs, because the historic parks generally do not appeal to the young. This gap may be filled by the Millennium Park, but it arises the need to separate the special and rather commercial functions from basic facilities, addressed to the local residents, who have waited for them since 30 years. The whole area occupies almost 100 hectares. divided up equally between an afforestrated ground and an area designated for recreational purposes. The authors encompassed a number of different initiatives, like a visioning project involving children, to create an approach based on partnership in the future.

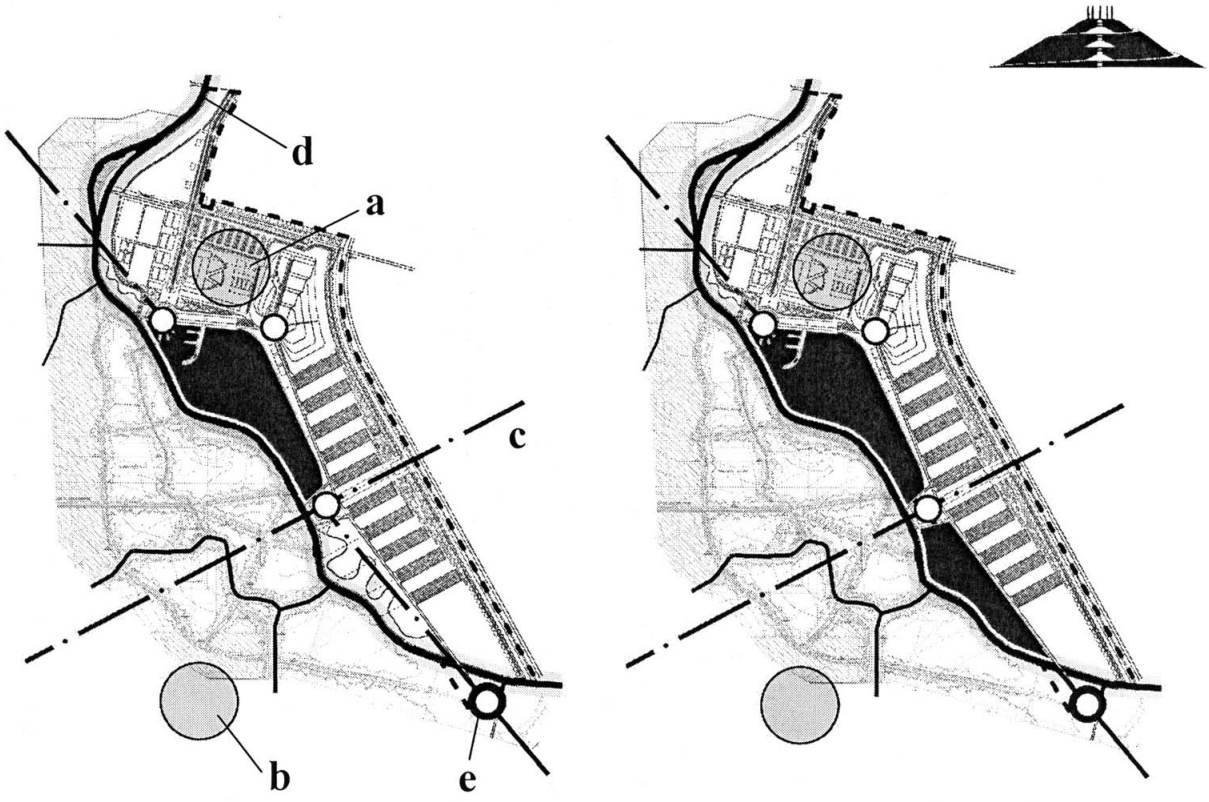

Figure 3 The "green poles" of activities in the Millennium Park: a) the north pole: a sport and entertainment centre including aquapark, adventure and water playgrounds, the skiing slope, marina and an artificial lake, b) the south pole: a planned shopping centre; c) axis of balance; d) main recreational links along the rivers, e) the main landmark (the Mound of the Piasts) – a counterpart to the People's Hall.

In consequence, the playgrounds, picnic areas and dog-runs are located close to the housing estate while the main attractions, as an artificial lake, adjoin the river and a parking area at the outskirts. In summer the lake can be used for sailing and pedal boating, in winter – for

iceboating. A hill nearby, with climbing walls and an artificial slope for skiing or sledge riding, will be formed from the earth excavated from the basin. Unlike the other part of the grounds, this section will be fenced and the visitors charged for using the facilities. Offering this area to the private investors, the municipality is going to lower costs of the realisation.

2.2.2. "Close to Nature" Development. The park's project has won the national architectural competition as the most harmonious combination of social solutions and environmental approach. Located near the areas that were flooded in 1997, it also adjoins a large housing estate with a number of high-rise concrete buildings that stimulate a local greenhouse effect. Thus the lake has been proposed as the best way to stabilise the local climate and foster plant growth. At the same time the new landscaping provides more natural flood-control and water quality improvement. Two polders will be created within the park's boundaries: in normal water conditions, the upper one will function as a biological filter (damp meadow) and the lower as the lake, but both polders could be flooded if necessary. The damp meadow will be planted with marsh flora and appropriate amphibian species will be introduced. The plan provides for mostly local species (excluding allergenic plants) in order to re-create the natural biotope of the river valley and make the project more feasible from the financial and maintenance perspective (Figure 3).

2.3.Case Study 3: The Odra River Biological Corridor Management Project

The efficiency of green poles will largely depend on their links, especially the urban walk- and cycleways network. In the spatial context of the city, the river biological corridors seem to create the best conditions to developing the greenways system. The embankments are regulated. The vision of a regulated river has been developed in Wroclaw since the 19th century, when the first plans for the Odra-Danube channel were presented. Although the perspective on these issues has changed from over the years, the conflict between the traditional and sustainable options has delayed the preparation of the national programme of the Odra river management. The programme will strongly influence the urban development along the riverside and the case study is to protect the natural and cultural landscape values for the planned greenways network.

3. EDUCATIONAL AND SOCIAL ISSUES

The case studies undertaken by DSD academic staff in co-operation with the Bureau of City Development, had initiated changes in the methods of teaching. The students play important role in all research programmes. They are also encouraged to share knowledge and interact with various groups of interests in order to promote the vision of the green and healthy city.

3.1. Implementing New Methods

In 2001, in response to the perceived deficiencies in students' education, an eco-compensation methods and green buildings rating systems were introduced to the master's programme at the Faculty of Architecture. The students are given the task of finding an appropriate location and design a housing unit containing 20 flats. During the first stage they have to inventory the chosen location and its immediate urban surroundings, which is followed by the evaluation of the environmental value of the landscape before and after the proposed investment; the value is expected to increase as a result of the proposed investment. The second stage involves assessing of a building to be erected on the proposed site. The students receive a ready-made

plan (with all relevant technical data) of the building and a rating list created on the base of currently used Life Cycle Assessment methods. [GBT 2001], [LEED, 2001]

3.2. Visioning

The principle of shared responsibility for the city is still a relatively uncommon practice in Poland, therefore the case studies refer to only few examples of visioning and public discussion concerning green solutions. From the PR perspective, the Internet (especially websites), exhibitions, multimedia presentations at the annual Festival of Science in Wroclaw and contacts with elementary schools situated within or nearby the studied areas. Nevertheless, all presented studies are intended to establish a Citizens Steering Committees to carry out the realisation of the green plans.

4. CONCLUSIONS

It is difficult to anticipate the future results of the strategies, but the current ones are evident: a) the traditional approach has been rejected and ecologically sound programmes for other areas of the city are expected to follow; b) the „green poles of growth" concept proved useful at different scales of planning; c) the lists of combined social and environmental objectives, which illustrate the possibilities of growth in the case studies, should be transformed into the green rating system and promoted in the future.

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Leasing of infill components - New business model development for dematerialization of building related industry

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1. INTRODUCTION

Evolution of industrial ecology in building related economic activities is a key issue for fundamental improvement of resource productivity in construction. Yashiro (2000) proposed the idea of 'service provider' as a possible form of business model to enhance industrial ecology in building related industry. However, any good idea could not make any good impacts on industry and society without effective demonstration and illustration. By governmental financial support, the authors initiated the R&D project to create and illustrate possible form of service provider; It is a business model to lease infill components fabricated in off-site factories such as kitchen unit, bath unit and sanitary equipments etc. The paper presents achievements and lessons from the undergoing R&D project.

2. THE IDEA OF SERVICE PROVIDER FOR BETTER RESOURCE PRODUCTIVITY

Figure1 illustrates the idea of product provider and service provider. Product provider is the form of most of building related sectors. Product provider gets the revenue by providing 'products' (= buildings etc.) to customers. In most of cases, building related product providers submit bills of quantities to customers to prove the appropriateness of price of buildings. Larger quantity of resource input brings larger revenue to product providers. In another word, the decrease of quantity of sold products results in the reduction of the revenue of product providers. Thus, the nature of product provider has weak incentive to dematerialization. Alternatively, the nature of service provider illustrated below has incentive to dematerialization. Service provider gets the revenue by providing services to customers; here

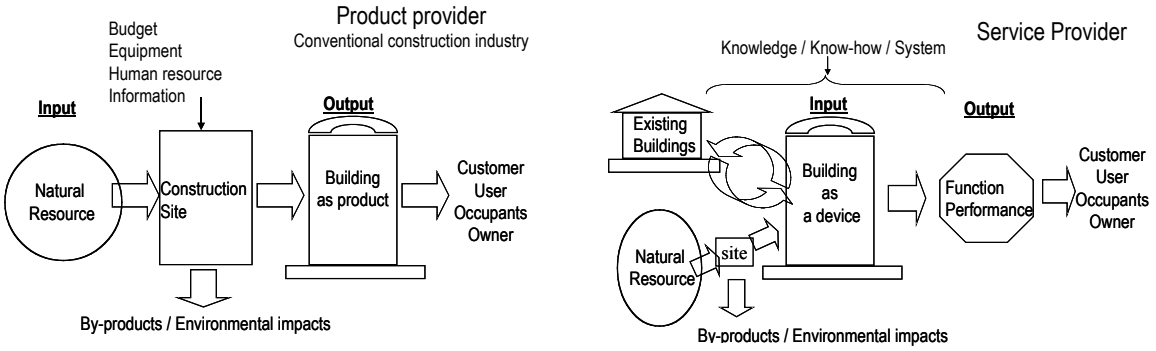

Figure 1 Product provider vs. Service Provider

services involve benefits from function, performance and psychological perception embodied with buildings. Prices of services are correlated with the quantity and the quality of services including magnitude of customers' satisfaction and degree of expertise to realize services. For service provider, building is a device for supplying services. It does not matter for customers whether the devices are brand new buildings or existing buildings, if the quality of supplied services is acceptable compared with price. For service provider, the quantity of resource input to building is a cost for supplying services. Thus, less resource input to devices of services could bring larger profit to service provider. Business model of service provider has potential to promote dematerialization of building related economic activities.

The transition from product provider to service provider is revolutionary change in building industry. Revolution needs driving force. Different from political revolution, the most effective driving force for industrial revolution is real examples that are successful enough to give impacts on holistic range of economic entities including fabricators, retailers, professions, investors, governmental agencies and citizens. This is the motivation why the authors initiated the new business model development project in domestic industrial contexts.

3. LEASING OF PREFABRICATED INFILL COMPONENTS

3.1 Contexts and motivation

Reality and state of art of off-site made infill components' fabricators are typical product provider. The revenue of fabricators depends on how many products are sold. They do not involve in the process of whole range of product life; in most of cases their task is completed when they sell their product to contractors, builders and end users through retailing agents

However, because of the following contexts in Japan, the authors judged that the leasing business of infill (= fit outs) components has certain seeds to generate sufficient feasibility and could be effective demonstration of service provider business model.

First, infill components' industry is powerful in terms of market share and innovation ability. Infill of contemporary Japanese buildings are, in a sense, assemblies of off-site made modules and equipments such as kitchen sets, 'bath units', sanitary equipments etc. Like automobile industry, the industry continuously supplies innovated and upgraded products compared with previous years. Growing new-build market over the last thirty years formed the basis of R&D investment.

Second, however, fabricators of off-site made infill components are seeking seriously new business area, especially in works to existing buildings because new-build market is apparently shrinking in Japan.

Third, current social and economic circumstances accelerate the transition of requirement by building occupants and residents. It is quite probable that installed infill one year ago need to be replaced to meet to the changing requirements. The idea of adaptable building, where base building is stable over time while infill are replaced frequently respecting on changing requirements by occupants and residents, is getting status of architectural paradigms of this century. Economically and socially serviceable life of infill components are getting shorter and shorter to the level almost equal to house automation devices like refrigerators, television, and washing machine etc. Change of requirements are not only caused by circumstantial conditions but also by continuous upgrading innovation of infill components like new electronic devices generate new demand.

Fourth, however, without measures of reuse and/or recycling, frequent replacement of installed infill components could have risk to increase waste production. Fabricators of off-site made components are feeling pressure from the principle of EPR (extended producer's responsibility), though at present products' lives are still believed to be 'too long' to make sense of EPR, while in reality, above mentioned rapid change of requirements are making

them not too long. The crud-sac to introduce measures for reuse and recycling is that most of off-site made modules and equipments available now in marketplace in Japan are too complicated and hybrid assembly of different kinds of materials. The state of art of off-site made infill components are too far from the policy of DFX (Design for X: X = environment, disassembly, remanufacturing, recycling etc.)

3.2 Potential benefit

Figure 2 illustrates the diagram of material flow of leasing business model compared with conventional product providing business model. In conventional business model as product provider, products are handled in one way flow from production, usage to disposal. By contrast, in leasing business model, products are returned to the supplier from the site of previous customer and re-manufactured for the succeeding customer. Eventually material flow draws closed loop.

In leasing business, customers pay fee to serviceability of products, not to the products itself. Thus, customers pay fee to the function and amenity derived from the usage of kitchen sets, 'bath units' and sanitary equipments etc. Here infill components are only 'devices' for service provisions. Thus, repetitive use of 'devices' reduces the cost for transaction procedure of business. Eventually leasing business is expected to have incentive to 'device' suppliers to create repetitively usable method of infill components as is illustrated in Figure 3. Leasing business model embodies the incentive to establish closed loop of material flow that is termed as 'inverse supply chain'.

By enhancing leasing business as package of long term maintenance and upgrading service, occupants and residents can enjoy assured quality of service embodied with functions and performance of components for duration of contract. Though there is a risk for suppliers' side on future expense for maintenance and repair, still it could be also beneficial for suppliers because of potential to increase business opportunities respecting on the circumstances of accelerated change of requirements together with the need of minimization of wastes from business processes.

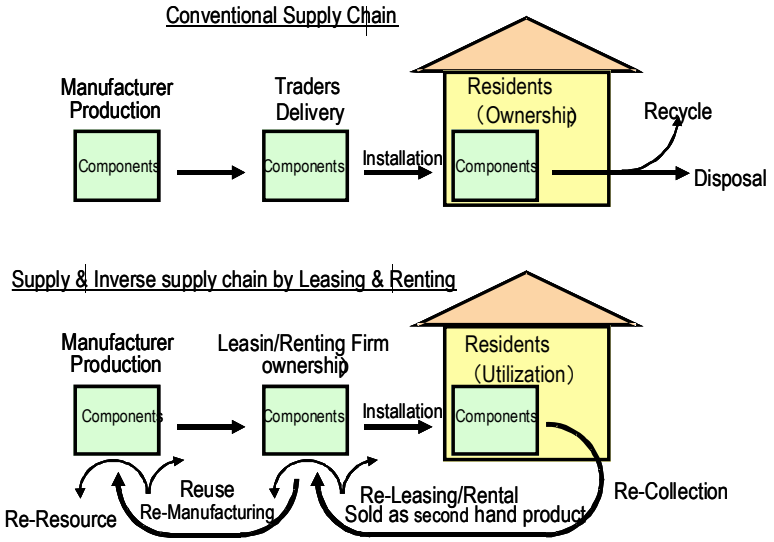

Figure2 Diagram of material flow of conventional supply chain and inverse supply chain by leasing business model

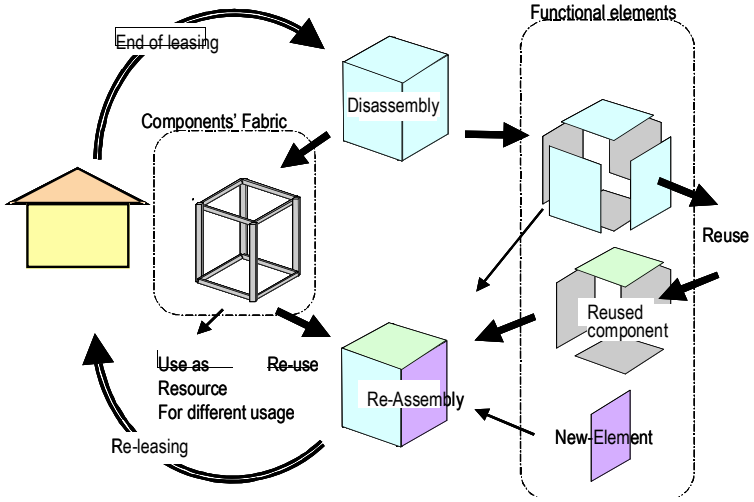

Figure3 Diagram of re-assembling of leased components

4. RESEARCH PROJECT

Respecting on the seeds in the industry and demonstrative significance, the authors called for member of informal research group to implement feasible study of leasing business of off-site made infill components. Academics and practitioner-researchers in the industry joined the group. After six months' study, the group made research proposal to the research fund from the government. The proposal was successful; the project titled as 'Morphological technology development toward redefinition of improved urban amenity' was started in August 2001.

4.1 Key technologies being developed

The research project identifies and focuses on the following key technologies to enhance the feasibility of the business model.

- Contract model based on service level agreement.
- Integrated IT tools to manage business operation
- Prototype of demountable infill components

4.1.1 Contract model based on service level agreement. Adverse and conflict relation between suppliers and customers degrade the feasibility of leasing business. So far there is not any agreed framework and yardstick in terms of quantification of 'services' that give basis of payment. Thus, it is a key issue to create contract model that is usable as templates in actual business practice. In the research project, contract model is being developed respecting on the following precedents.

- Performance based contract in building practice
- SLA (Service Level Agreement) disseminated in information & communication service industry that give clear definition of the scope and level of services provided by suppliers

4.1.2 Integrated IT tools for business operation. Running leasing business requires continual exchanges of various information between customers, supplier as well as stakeholders. The exchanged information involves those relating to contracting, design, fabrication, installation, logistics, maintenance and replacement etc. Those information need to keep consistency over time and accessible any time from any authorized agents within suppliers' organization and stakeholders. Thus, IT tools together with operating process design is a key issue to make the leasing feasible. In the research project, fundamental

framework of information operation is being designed together with protocols and format of database.

4.1.3 Prototypes of demountable infill components Repetitive use of infill components is a key issue to enhance eco-efficiency and resource productivity of the leasing business. However, as it is already mentioned, mainstream of off-site made infill components are hybrid and complicated assembly of unnecessarily various materials and elements with poor standardization in terms of shape, size and interfaces. The state of art of 'devices' for the leasing business stands on the opposite position against DFX (Design For X) policy. There is a need of demonstration of what is demountable infill component. Thus, prototypes of demountable infill components are being developed based on DFX policy.

4.2 Organization for all-in-one

Magnitude of added value of infill components' leasing business model depends on degree of customers' satisfaction, but not on the quantity of material resource input. Performance and function of infill components as 'device' correlates to the customers' satisfaction, but those are only significant elements of customers' satisfaction among various factors. What customer feels if poor maintenance and operating service are supplied? How customer reacts to poor coordination of services that enforce customer frequent search of directory of contacts? Organization to supply lease services to customer needs to be capable of integration and coordination of services including design, installation, and maintenance of 'devices' over time. Core source of added value in leasing business is not only good quality infill components but also integrated and coordinated finance, information, design and management. Here 'all-in-one' is significant criteria for better customers' satisfaction, while very few firms and organization can involve whole range of required resources to all-in-one service.

The model of alliance organization emerges where a kind of SPC (Special Purpose Company) stands on the center of alliance. For customer, SPC is a single responsible body in terms of design, delivery and installation of 'devices', maintenance and upgrading (if requested) and so on, while SPC outsource necessary resources from circles of alliance of firms, organizations, investors, and professions. Core function of SPC is management capability for integration and coordination.

Figure4 Diagram of mock up experiments

4.3 Mocking up experiments

Figure 4 illustrates the composition of mocking up experiments. Here infill is divided into two layers. One is the lower system where pipes and wires are installed under the floor panels. The layer is called as interior infrastructure; domestic law probably identifies the layer as fixed property. The other is upper system composed of leased modules and equipments. These are expected to have movable property status and to be treated independent property from fixed property in domestic law, which gives SPC the basis of calling for finance from investors to run the leasing business under the assurance of certain mortgage. The result of mocking up experiments shows the feasibility and effectiveness of the diagram illustrated in Figure 4. However, the experiments also left the lessons that identify the problems in terms of buildability in site. The project now moves on to the second year. The problems identified are now being solved in the framework of academic-industry partnership.

5. CONCLUDING COMMENTS - FUTURE EVOLUTION

The achievement of the undergoing research project so far proves that leasing of infill components has sufficient feasibility in the context in Japan. The key technologies and mocking up experiments suggest that leasing of infill component business would generate fundamental improvement of resource productivity in building related economic activity. The research project is drawing concern by industrial agents and by general public in Japan. They are learning that repetitive use of 'devices' and focus on works to existing building could also produce the comparable added value with new-build business. The research project is expected to give impacts on cultural change from 'product to service' in building related activities.

However, mocking up experiments also left lessons and problems to be solved to enhance feasibility and productivity of the leasing business. Key word is 'interface design'. Most of all problems identified in the mock up experiment are rooted in the poor coordination of interfaces of physical joints between modules and equipments, interface of exchange of information, interfaces of site organization, activities and liabilities.

When the research project completes to prepare the solution to the problems in interfaces, the business model of leasing of infill components could be driving force of dematerialization of building related activities in Japan.

6. ACKNOWLEDGEMENT

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The Centre for Sustainable Building (ZUB)*
A Case Study

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1. INTRODUCTION

The primary energy demand of residential and commercial buildings still counts for about one third of the total world energy demand (ECBCS 2002). Therefore, energy efficient building with the lowest possible impact on our natural environment is much more than a demand, it is a need in the entire building process.
The ZUB office building is an example of how new low temperature heating / cooling systems and strategies have been implemented and new environmentally friendly building materials can be used. It illustrates how new efficient systems and strategies can be realised in practical building projects.



Figure 1 The office building of the Centre for Sustainable Building (Meyer 2001)

Nowadays an environmentally friendly and sustainable building process is an interdisciplinary task. Only a close teamwork of people from different building related disciplines makes it possible to face the challenge of answering these questions and real life problems. That is one

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reason for the foundation of the Centre of Sustainable Building at the University of Kassel, Germany. But, not only building research and the development of integrated planning processes in the field of building are conducted within the walls of the centre. Moreover, the centre is a platform for the fast implementation of research results into practical building processes. It offers a variety of different services in research and development, in education for all kinds of people who are interested in building (professionals and non-professionals). Furthermore, public relation activities are carried out at ZUB to introduce the ideas of better, more efficient and reliable building with the smallest possible impact on the environment.
The building of ZUB is an example of what today's state of the art technology of low energy demand and sustainable building can look like.

2. THE BUILDING CONCEPT

The office building of the Centre for Sustainable Building is situated at the University of Kassel, in an old urban neighbourhood. The new building of the ZUB closes a gap between an ensemble of old houses. An atrium, used as a light gap, which contains the entrance zone and the staircases, joins the old brick building of the Faculty of Architecture to the modern concrete construction, joining them to form a combination of old and new (see Figure 1).

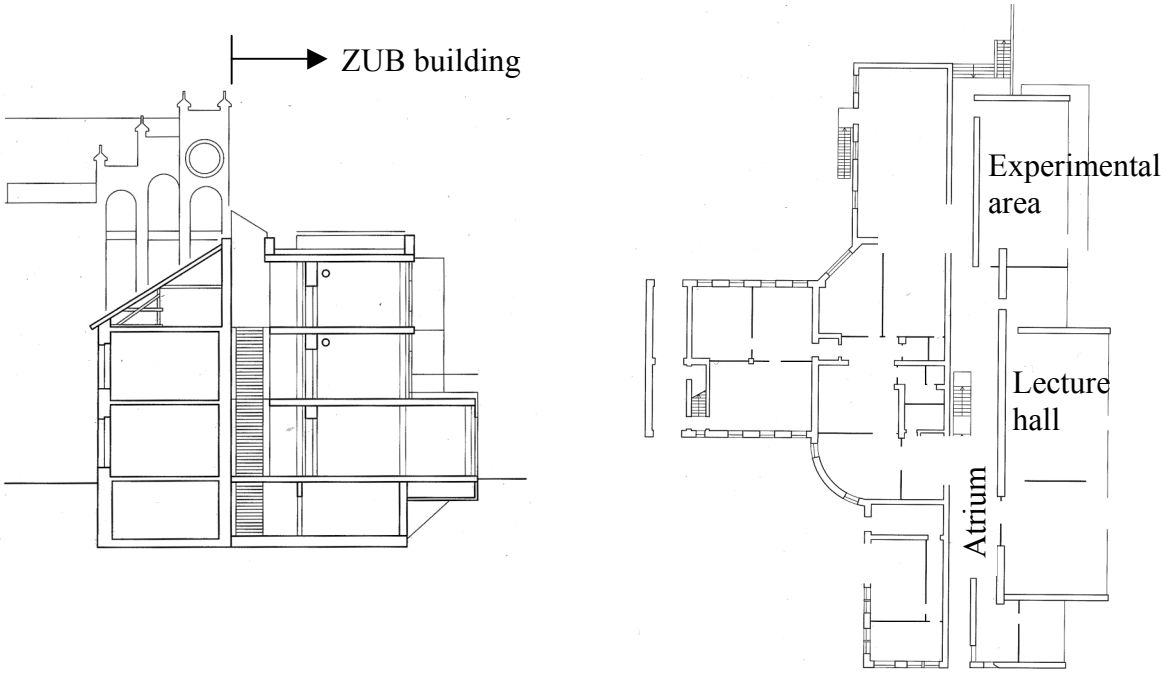

Figure 2 Section and floor plan of the ZUB building (Seddig 2000)

The ZUB office building consists mainly of three different parts: one part for exhibitions and events, one part for offices and an experimental part for different kinds of research in innovative building technologies and building services concepts. On the flat roof, some space has been provided for test equipment in non-shaded conditions.
The load bearing skeleton in reinforced concrete consists of round pillars with a distance of 5.40 m and flat concrete slabs for the floor / ceiling construction. The U-value of the exterior walls is 0.11 W/m²K and triple glazings with a U-value of 0.6 W/m²K have been chosen for the mainly south facing large window area. The minimal frame-fraction of the wooden facade construction helps to reduce heat losses and the problem of thermal bridges has been diminished by the careful planning of all joints and details. A good thermal insulation is mandatory in achieving minimal heating energy demand for the entire building.

Table 1 Main building facts

Volume	6882 m^3	Building part	U-value
Net floor area	1732 m^2	Exterior walls	0.11 W/m^2K
Main floor space	830 m^2	Roof	0.16 W/m^2K
		Windows	0.80 W/m^2K
Area/volume ratio	0.34 m^{-1}	Wall/floor against ground	0.26 W/m^2K
		Mean U-value	0.32 W/m^2K

Calculated heating demand (acc. to energy code WSVO'95) 5.3 kWh/m³a or 16.5 kWh/m²a

Costs:	Construction	+	Services equipment	=	Building costs
per volume	249 €/m³		97 €/m³		346 €/m³
per net floor area	988 €/m²		387 €/m²		1375 €/m²



Figure 3 Inside view of an office room (Meyer 2001)

3. THE ENERGY CONCEPT

The office has been planned as an example of a low energy building. To reach this aim, the planned annual heating demand was projected as less than 20 kWh/m². It turned out to be 16.5 kWh/m², which is only 27% of the limiting maximal value, according to the German Energy code "Wärmeschutzverordnung 95". To save electrical energy, both natural lighting and even ventilation strategies have been implemented. Solar gains are utilised through the glazing of the south facing façade. At the same time, a good thermal and indoor comfort for the occupants was a major demand from the building owner.

To monitor the aims and verify the concepts and achievements, an intensive research project for "solar optimised building"** is currently being run. Over a period of four years, all the planning and construction processes are being followed up and, for at least two years, measurements of all important parameters of this building are being drawn out. Approximately 1300 measurement points, such as temperatures and heat and energy flows,

** Solaroptimiertes Bauen; Teilkonzept 3, research programme funded by the German Ministry of Economy and Technology

are being monitored. In addition, the thermal / indoor comfort and indoor air quality is being reported and controlled. Studies on the building behaviour are being done in two especially equipped office rooms. Detailed system studies on components (heating and ventilation system) are being drawn out, the entire building is supervised, and the overall energy consumption is being reported.
Furthermore, the ZUB office building is a demonstration project for the IEA ECBCS Annex 37 “Low Exergy Systems for Heating and Cooling of Buildings”.

3.1 Systems for heating and cooling

To achieve the heating and cooling of the offices using one system, only a hydronic conditioning system with embedded pipes has been chosen. In the case of heating, the system works with low inlet temperatures (approx. 24° C, outdoor temperature dependent). When cooling is necessary, pipes in the floor slab construction of the basement, the ground heat exchanger, cool the water. Ground coolness, a renewable and environmental energy source is utilised and a mechanical cooling machine is not required. The conditioning concept shows how a low energy system can be designed using today’s technologies.

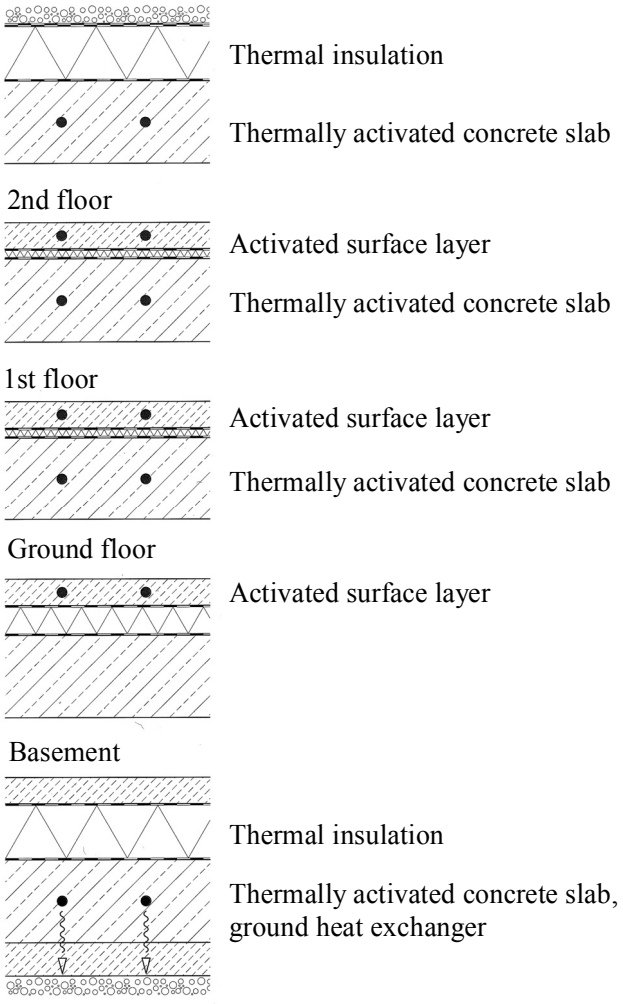

Figure 4 Position of the different layers of pipes in the concrete slabs

As shown in Figure 4, the pipes are embedded in the concrete floor slabs and in the upper floor construction. The slabs are thermally activated and in addition, a conventional floor heating system has been placed on top of them to test the properties of different systems and

their advantages. Since each room has its own heating circuit, individual regulation of the thermal conditions is provided. Normally, the systems operates with a low constant inlet temperature, using the self-regulation effect of this system. It is not possible for the room temperature to exceed the inlet temperatures of the pipes and if the room temperature is higher than the inlet temperature, the system will cool, even in the case of heating. The thermal comfort in these offices is very high because of the even and relatively high surface temperatures.

3.2 Ventilation strategies

To reduce ventilation heat losses, mechanically balanced ventilation using heat recovery with two cross flow heat exchangers in a series and a thermal efficiency of 0.8 has been installed. In the normal operation mode, fresh air is supplied directly to the office rooms and exhaust air is extracted from the atrium, then transported to the heat recovery unit. For research purposes, the air flow direction is reversible. The fresh air can be supplied to the central atrium and the exhaust air extracted from the office rooms.

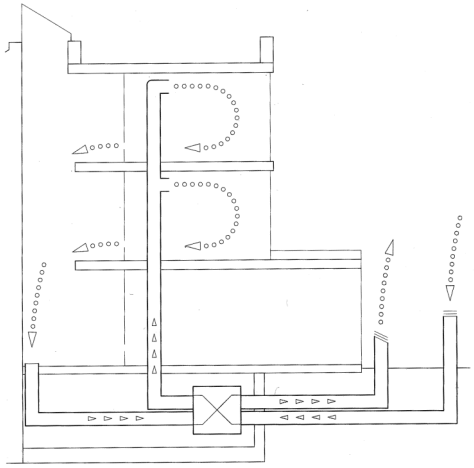

Figure 5 Fresh air supply directly to the offices and return air via the atrium (Hausladen 2000)

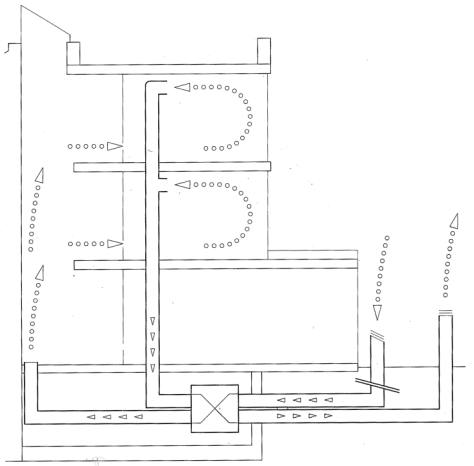

Figure 6 Fresh air supply to the atrium and exhaust air from the offices (Hausladen 2000)

The air flows are regulated via indoor air quality sensors (VOC) and the ventilation is demand controlled. The design air flow, with 4000 m³/h, is too low to supply the offices and the fully occupied lecture hall, which has its own direct ventilation supply from the AHU (Air handling unit). When the overall delivered airflow is not sufficient, the offices are ventilated by natural means. Fresh air is supplied via the open windows in the offices and exhaust air leaves the building through openings at the top of the atrium. The stack effect of this high building helps in ventilating without fans. For this ventilation strategy, no heat recovery can take place, but it has great advantages for night cooling. The building structure is cooled during the night by a massive flow of cold ambient air.

4. OTHER SYSTEMS

There is a clay wall, made from massive unbaked clay bricks, in the centre of the building and on all floors. This wall, with its great heat capacity and the capability of dampening fluctuations in humidity, can be seen as a climate wall. It also provides the space necessary for electrical and ventilation installations. The function of this wall is also monitored.

The building is equipped with a building management system. All building service functions are controlled and the components, like ventilation and heating equipment, are regulated. The

measurements for the research programme are done via the building management system. An optimisation of particular building components will be conducted, based upon these values. Furthermore, new strategies for energy management systems in buildings are going to be developed and tested.



Figure 7 View inside the atrium, it shows the open thermal masses and the internal clay wall used for all the installations (right hand side) (Meyer 2001)

5. CONCLUSION

The ZUB building is actual proof that it is possible, using today's construction technology, to combine the demand for energy efficiency with sustainable building. This can only be achieved by having a well-designed integral planning process and a close teamwork of all participating parties. An example of this is, shown by ZUB, where the hydronic heating/cooling system has been merged into the building structure, an entirely new challenge for planers and builders.

Measurements (Approx. heating energy 26.7 kWh/m²a, approx. electricity consumption 10.7 kWh/m²a) of the first heating period, indicate that the demand for low energy use has been fulfilled.

6. ACKNOWLEDGEMENT

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Re-Development of Urban and Rural Areas in Westafrica: a Critical View on Indicators for Assessment of Land-Use Options

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1. INTRODUCTION

Uvwie Local Government is a booming area in the south of Nigeria (Westafrica) in Delta State: It is strategically located being the centre of Urhobo kingdom and as a result became a perfect location for the site of oil related industries. The opportunity provided by these caused people to gravitate to it thereby creating immense population explosion. During the last 10 years population increased from 350.000 to 2.000.000 inhabitants, but infrastructure remained dormant, which means: there is no sewage system, no waste disposal system, no water supply, insufficient energy supply, traffic congestion due to lack of transportation infrastructure, no public amenities such as library, theatre, movie and sport fields. In connection with this lacking infrastructure and basic amenities associated issues come along such as diseases due to waste and in some cases excrements flooding into residential areas during raining season, air and soil pollution due to traffic and oil industry, youth restiveness and crime due to high unemployment rates, hunger, and lack of opportunities to occupy themselves. The illiteracy rate is high, up to 70 percent among women, and about 60 percent of the people are living far below the poverty line. Traditional knowledge is getting into extinction without any hope of being substituted by the so called western education: Schools are expensive and parents cannot afford the astronomical fees. As a result most children are forced to stay home and do menial jobs to help their parents instead of being in the class room. Primary school that is supposed to be compulsory is fees bound, not to talk of the secondary and the tertiary institutions.

Relief can only be achieved by completely restructuring the region. A well co-ordinated and adapted effort in land use planning is needed to build a sound basis for development. Good land use planning can provide shelter and employment without negative impacts on the environment and therefore increase the quality of life: Determination of land use is a powerful instrument for sustainable settlements development.

Strategic assessment of land use options provides the basis for elaborating optimised land use plans. In Europe, the method of Strategic Environmental Assessment is applied for early examination of plans in order to avoid negative impacts.

2. STRATEGIC ENVIRONMENTAL ASSESSMENT AS AN INSTRUMENT FOR SUSTAINABLE LAND USE PLANNING

In Europe, the European Directive on Strategic Environmental Assessment (SEA) was issued in July 2001 and must be implemented in the European countries by 2004. The directive requires that plans, programmes and politics (such as land use planning) have to be analysed

regarding environmental impacts in order to integrate environmental issues into the decision making process.
The core of a Strategic Environmental Assessment (SEA) is

1) the development and comparison of alternative solutions in order to elaborate an optimised solution, and
2) the participation of relevant groups who develop targets and indicators together with experts in order to compare alternative options.

In Europe, several SEA have already been carried out on a voluntary basis, some of them not only integrating environmental issues into the decision making process, but also the two other sustainability issues these being social and economic aspects. If all three aspects of sustainability are considered in the course of a strategic assessment of policies, plans and programmes, this will be a powerful agent of change towards a truly sustainable society. In this article, we use the term “Strategic Sustainability Assessment” for the SEA that equally considers all three aspects of sustainability.
While participation is sometimes difficult to achieve in Europe, participation has had a long tradition in the Westafrican cultures. From this perspective, the precondition to carry out a “Strategic Sustainability Assessment” for land use planning in Uvwie Local Government, Uvwie Kingdom, respectively, seems to be good, but how about the administration of the process and the results, which indicators to develop? In order to deal with these questions, we have to take a closer look at the historical background and the present practice of administration.

3. THE POSITION OF UVWIE IN THE TRADITIONAL AND ADMINISTRATIVE PERSPECTIVE

Uvwie Local Government is one of 25 Local Governments in Delta State. Delta State is located in the south of Nigeria in the oil producing region; it is one among 36 Nigerian states. Counting about 120 million inhabitants, Nigeria is the most populated country in Africa. Uvwie kingdom is one of the Urhobo kingdoms: The Urhobo people are mainly in the core Delta State and the tribe is defined by a common language with about 5 million people who organise themselves in clans. Each clan forms an administrative unit, the kingdom. A king is elected for a life time, but the clan has the right to banish him if he does not adhere completely to the rules. Kingship is not hereditary like it is practised in European monarchies, the king is elected among the families nominated to be kings. The elders of a particular district, all men within the clan known as king makers, have the spiritual authority conferred to them by the clan to elect kings. Kingship is strictly men affairs as Uwvie is patrilocal like many other areas in Nigeria. The most important condition for being a candidate is to belong to one of the royal families and be a dedicated male child because this is the guarantee that he will feel responsible for the area he will govern for a life time.
However, the traditional system in Uvwie falls under the local government and chieftancy affairs. Its position is tragically subjugated to the whim and caprices of the Federal Government who has the prerogative over the clans. At the federal level there is a political system with three political parties, PDP (People's Democratic Party), AD (Alliance For Democracy), and APP (Advance People's Party). This system is the executive system modelled after the USA with an executive president, state governors and mayors. So - what is the position of the traditional system? In fact, the "mayor is just for the political relation with the federal government, but the king and his district chiefs who report to him, deal with all the important issues". Among the important issues is the land issue, because in the past land belonged to the king by default. In order to understand the land issue in Uvwie, we have to take a closer look at history.

3.1 History of land use in Uvwie

Nigeria was an administrative unit, but not a nation. Nigerians identify themselves as Urhobo, Ibo, Yuroba, Hausa or any other of the 220 tribes with their own languages. Uvwie came into existence in the 11th century, when some families escaped from the former Ogiso dynasty (in Benin) to the region of today`s Uvwie Kingdom. They left because of the brutal Ogiso rulership and migrated to a very promising region: fertile land, a river, the sea nearby and virgin. The families settled down and remained fishermen, hunters and farmers. They set up a society and selected a king among themselves who became the natural custodian of the land. The king had the prerogative to distribute land to the families according to their size: the more family members, the more land they got. Borders that existed before colonialism were invisible but correctly known by the indigenous and owners and naturally there was harmony and understanding. This is not only peculiar to small communities but to national levels. With the advent of colonialism the border situation changed and scrambling for land with absolute impunity became the accepted standard. There was no regard for customary rule, it was visited with ferocious western weaponry. The end result was border irredentism. The end of colonialism in 1960 opened a new era with high hopes which ended in coups and counter coups in the Sixties and finally in dictatorship that lasted until 1999. It was in this period after the end of colonialism in the year 1960 when oil became the focal point dictating the country`s destiny. Exploitation started in 1970, the boom period.

In the pre colonial era the king was responsible for land use, he determined which land was allocated for which purpose. In the colonial era this power remained: even though the king had no official position, no decision about land use was taken without his approval because "protectors" realised the advantages of using traditional systems for their own administration.

In the Seventies, the oil boom opened another chapter in land use: In 1978 the former dictator Obasanjo (who today is the democratic president) issued the "Land Use Decree", saying that all the land belongs to the government alone and any land that delivers oil may be taken for exploitation. Now for oil producing companies abroad it was easy to achieve the permission for land use because this was the official Nigerian strategy. At that time during dictatorship the king had no official power but in fact he and his district chiefs were the people who kept daily business going. From the traditional background, the king would have been in the position to object against oil exploitation, or at least in the position to place conditions. However, he did not because he was not aware of the consequences that lead to pollution of soil, water, and air and to high rates of cancer. The tradition of "dashing you something" at any occasion turned into the habit of corruption, that lead to total confusion and mismanagement.

During dictatorship the enactment of laws such as the "Land Use Decree" paved the way for oil producing activities, for the construction of an airport, for construction business and other actions. Nobody went against this erratic, and despotic rule, so as not to be killed. After the end of dictatorship, agitation for land started. Although Nigeria is under democratic rule, the "Land Use Act" of 1978 is still in force, posing a major barrier to any local initiative and hindering sustainable land use. Decisions are made in Abuja, a 10 hours` journey by car from Uvwie. There is a master plan providing a picture of how the regional development has been planned by the state government. However, the local governments are hardly, not to say not at all involved in the elaboration of the regional development plan. New approaches that give hope such as "Local Agenda 21" remain a theoretical concept under the present conditions.

4. INDICATORS FOR STRATEGIC SUSTAINABILITY ASSESSMENT (SSA) IN UVWIE

Within an SSA, targets to be achieved by the options under discussion, and indicators used to describe and compare these options should be determined by the people affected by the new development. Several indicator systems can be referred to as a starting point: Comprehensive indicator systems can be useful as a checklist for elaborating the indicator system for the SSA to be carried out, in order not to forget important aspects.

Kopfmüller et al. (2001) reviewed and compiled existing literature and published a comprehensive list of targets and indicators for sustainable development, aiming at covering the ecological, economic and social dimension of sustainability. According to Kopfmüller et al. (2001) this list is applicable to all cultural settings, economic and political systems.
They say that every measure, plan, programme, project, etc. must contribute towards achieving the following three targets of sustainable development:

1. Preserve human existence on earth;
2. Maintain the social productivity potential;
3. Preserve society`s options for development and decision making

For each of these targets they define sub-targets that are listed in the following table.

Table 1 Targets and sub-targets for sustainable development

Target	**Preserve human existence on earth**	**Maintain the social productivity potential**	**Preserve society`s options for development and decision making**
Sub-targets	Protect human health	Sustainable use of renewable resources	Equal chances with respect to education, job and information
	Assure supply to cover basic needs	Sustainable use of non renewable resources	Participation in social decision making processes
	Provide opportunity for autonomous subsistence	Sustainable use of the environment as a sink for emission and waste	Preservation of cultural heritage and cultural diversity
	Justice in access and utilisation of natural resources	Avoid technical risks that are not justifiable	Preservation of cultural functionality of nature
	Balance extreme differences in income and wealth	Sustainable development of capital with respect to material, human resources and knowledge	Maintenance of social resources

For each sub-target they list indicators that describe whether or to which degree a measure, plan, programme, project, etc. contributes to achieving the sub-target.
According to Kopfmüller et al. (2001), these are the 10 most important requirements an indicator must fulfil in order to deserve being named as an indicator:

1. Transparency about selection of criteria and method of aggregation;
2. Transparency about quality of data;
3. Data availability;
4. Reasonable effort for data collection;
5. Reproductability of results;

6. Sensitivity with respect to changes over time;
7. Usefulness for description of trends;
8. Usefulness for political control;
9. Political and societal agreement on the interpretation of the indicator;
10. Early warning function.

They also name the usefulness for international comparisons, but limit it to industrialised countries. This is correct because conditions in industrialised countries are completely different from the situation in developing countries. However, this is also true for other aspects in this requirements list. There are especially vast differences with respect to culture and societal values, criteria and data availability. This means that indicators for conducting a SSA in developing countries will also be different.
The targets and sub-targets listed in table 1 can be used as a check list for target definition for land use planning. Indicators to describe and compare options, have to be different and have to be elaborated according to the cultural background and the current potential with regard to data availability. To give an idea about the differences, the following table shows an extract of criteria and indicators for sustainability targets compiled by Kopfmüller et al. (2001) for industrialised countries, and the corresponding indicator we would suggest for the conduction of a SSA in Uvwie.

Table 2 Criteria and indicators to describe whether a programme, plan or project contributes to achieving the sustainability targets (extract)

Criteria	**Indicators for industrialised regions suggested by Kopfmüller et al. (2001)**	**Indicators suggested for conducting a SSA in Uvwie / Nigeria**
Existence security	Quantitative indicators: • Share of population who owns an insurance policy	Qualitative Indicators: • Social structures in the community that care for people without income or sustenance
Human Health	Quantitative indicators: • Number of medical doctors per 1000 capita • Life expectancy in years • Mortality of children	Qualitative Indicators: • Access to affordable medication • Single use of medical equipment instead of multiple use in hospitals • Availability of the "public pharmacy" (Dogoyaro Tree, Bitter Leaf and other plants) Quantitative indicators: • Life expectancy in years • Mortality of children
Nutrition	Quantitative indicator: • Share of overweight population	Quantitative indicator: • Share of starving population
Housing	Quantitative indicators: • Number of square meters per person • Number of homeless people	Qualitative Indicators: • Management of sewage and waste disposal • Energy supply • Water supply Quantitative indicator: • Number of square meters per person

		• Number of homeless people
Education	Quantitative indicator: • Share of illiterate population • Share of young people without degree • Share of young people without a profession	Quantitative Indicators: • Share of illiterate women • Share of illiterate young people • Average age of completion of primary school, secondary school, and high school

While in industrialised countries availability of data is good and quantitative indicators can be defined, in Uvwie in some cases we have substituted them by qualitative indicators due to lack of statistical data. However, in some cases the indicator suggested for industrialised countries are irrelevant for the conditions in Uvwie, such as “share of population who owns an insurance policy”. “Insurance” as we know it in Europe does not exist at all, but in Uvwie culture people developed social structures to cope with insecurity in every day life. Quantitative indicators such as illiteracy rates among women lack data, as well, but are based on discussion and debate. In Uvwie, participation is not just a term, it is part of the culture and people have a good feeling for their environment.
In fact, Uvwie is based on the spiritual centre located close to the market. Foreigners who are not familiar with this way of spirituality will never expect that area to be something special: there is no building, no sign, nothing that would give you a hint that this is a special place. But the indigenous start every important project, event or initiative from there. With a traditional ritual, the representatives of the Uvwie people "open" the place and bring their chairs to sit down for debate. And "if you take away this place from the community, there is no Uvwie no more". Among other functions, it is the responsibility of the spiritual leader to keep the land documents that tell you, which land belongs to which family.

5. CONCLUSION AND FUTURE OUTLOOK

Chapter 4 points out that conducting a Strategic Sustainability Assessment in Uvwie is possible. Actually, a Local Agenda 21 process started in January 2001, the ground is prepared. However, as long as the “Land Use Decree” is still in force, all local efforts will be in vain because they will be overruled by the Federal Government in Abuja. Right now, Uvwie is confronted with single isolated measures such as an overhead bridge as a solution to the problem of traffic congestion. In fact, this overhead bridge will not solve anything, but only shift the problem to another dimension. International documents issued by the United Nations stress the important role of regional initiatives and in Uvwie we have realised the potential for developing an optimised solution for land use – optimised with respect to the economic, ecological and social aspects of sustainability. Uvwie is ready to make a change towards sustainable development - if the Federal Government of Nigeria allows us to do so.

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Sustainable Construction Agenda. www.csostenible.net

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1. INTRODUCTION

The *Sustainable Construction Agenda* (www.csostenible.net) is a Web Site specialized in Environment and Construction, and was born with the objective, among others, to agglutinate all the available information upon this theme. In the framework of the fair Construmat '99, was done the public launch of the Web and we began to do diffusion in general and sector media; this process culminated on 2001, with a new design of the web and with the start of a new phase that began during the edition of Construmat'01. After more than two years "on line", and with more than 90.000 visits received, The *Agenda* has become a referring when we talk about construction and environment, and a meeting point of all the professionals, manufacturers and users interested in building healthier buildings and reducing environmental impact on Spanish area.

The AgendaCS is a project promoted by the Association of Technical Architects of Barcelona, carried out jointly with the "Architecture School of Vallès, of the UPC (Politechnical University of Catalonia) " "GEA" (Geobiological Studies Association), and Cerdà Institute, with the common objective of unifying efforts to contribute to a reduction and improvement of the environmental impact of the construction.

The main objectives of the project are:

> To give answer to the lacks that the professionals of the architecture and of the construction has when trying to introduce sustainable parameters in all the constructive process, selecting materials and in the phase of execution of the projects of buildings and Civil Work
>
> To become the meeting point of professionals, businesses, institutions, students and also of users, where they can find the information that need, in the environmental aspects of the construction. That's to say, to know the last news in ecological materials, the most interesting publications, the activities all around the world, some examples of good practices of sustainable buildings and all that related to this theme as specific as is the sustainable construction.

2. CONTENTS

Agenda offers information, permanently updated, about novelties, activities, professionals, enterprises, products and materials that make easier the introduction of sustainable practices in the construction process. The site offers two different ways for finding the information:

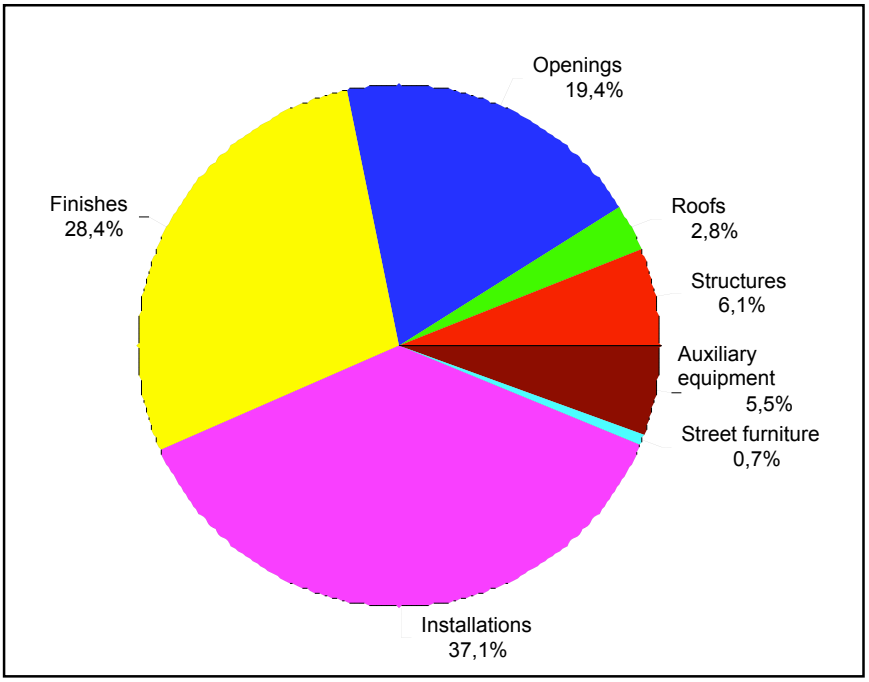
The sailing bar in the upper part of the home page
The 8 monographic pages

Using the tools of the sailing bar you can access to:

- ***Database of sustainable construction materials:***

  According to Our market studies, one of the biggest problems for the introduction of environmental improvements in buildings, is the difficulty for finding environmental friendly products in the local construction products market. The continual work of the agenda of sustainable construction to research information and promote environmentally sound construction materials, products and services has result in a database, which, compiles more than 700 products and 600 enterprises. The database has tolls to make this data accessible and thus promote the construction of more sustainable buildings.

  Studying the products we have compiled, we can see that there is significantly more environmentally sound products available in sub-sectors of the construction market where eco-labels exist (see figure below). This suggests that the construction industry is more responsive to calls for improvement in areas of rigorous legislation or clarification of environmental issues such as the chemicals industry (manufacturer of paints and varnishes).



- ***Newsletter Sustainable Construction:***

  The monthly Newsletter "Sustainable Construction" is the tool that allows us keeping contact with our subscriptors. Each month there's a monographic about an actual theme, and there are too, the regular sections about activities, books, news and related links to the monthly theme. All the past newsletter, can be found in the historical page in the site. Following there are few of the themes treated the past year:

  HCFCs and Halons in construction
  Urgent measures against legionella
  Forest certification
  Decontamination and elimination of PCBs
  Acoustical contamination

  There's too a distribution list, which has about 500 members, who receive the newsletter and participate in the discussion forum.

- ***Library:***

  In this part, you can access to guided searches to the databases of the Documentation Centre of the Association of Technical Architects of Barcelona, where among others you can find a commented compilation of the best titles about sustainable construction

- ***Legislation and subventions:***

  It's a database of aids that can be obtained of the different administrations, so much to local level as autonomous and national, and a legislation Data Base on normative of local, autonomous, and national environment, referred to environmental aspects of the construction. The search is carried from a web page, where consultations can be carried out combining the territorial area of application of the disposition (European, national, autonomous and local) and the theme. Because of it, the dispositions have been analysed in depth, with the objective to classify them in themes easily identifiable and thus to be able to make the search faster. The topics considered in this classification have been the following:

  -Water
  - Air
  - Wastes
  - Products and materials Certification
  - Energy
  - Territory
  - Environmental quality of indoor air and noise

- ***Activities Agenda:***

  Different activities such as courses, journeys, seminars, congresses, fairs and other acts and events all around, upon themes of construction, urban planning and sustainability can be consulted.

- ***Links Data Base:***

  Database that has classified more than 120 selected web sites about construction, urban planning and sustainability.

- ***Search Tools***

  A global search engine has been incorporated which, through key words, you can access to all the pages about the topic in the web site.

In addition to the tools and links in the *navigation bar*, the *Home Page* has 8 links to 8 monograph pages about topics on sustainable construction. For each page, some automatic links and searches to the different Data Bases and contents have been programmed. So, the users can access easily to all related information about a topic. This 8 topics and pages are:

- ***Urban Planning***

  Information on Urban Planning according to sustainable design.

- ***Wastes***

  All you need to know to manage correctly the construction wastes.

- ***Health***

  To know all the possible risks for the human heath about some normal construction practices and information about hazardous materials (for ex. asbestos).

- ***Energy***

  Themes about rational use of energy, use of renewable sources of energy, low energy consumption buildings materials and so on.

- ***Water***

  Information about the use and how to manage water, in order to reduce its consumption.

- ***Materials***

  The amount of materials used in the construction of a building is very important. Using low impact materials, contributes to reduce the global impact of the building. In this chapter, you can find all the related information about materials, where, what and how to use them.

- ***Good Practices***

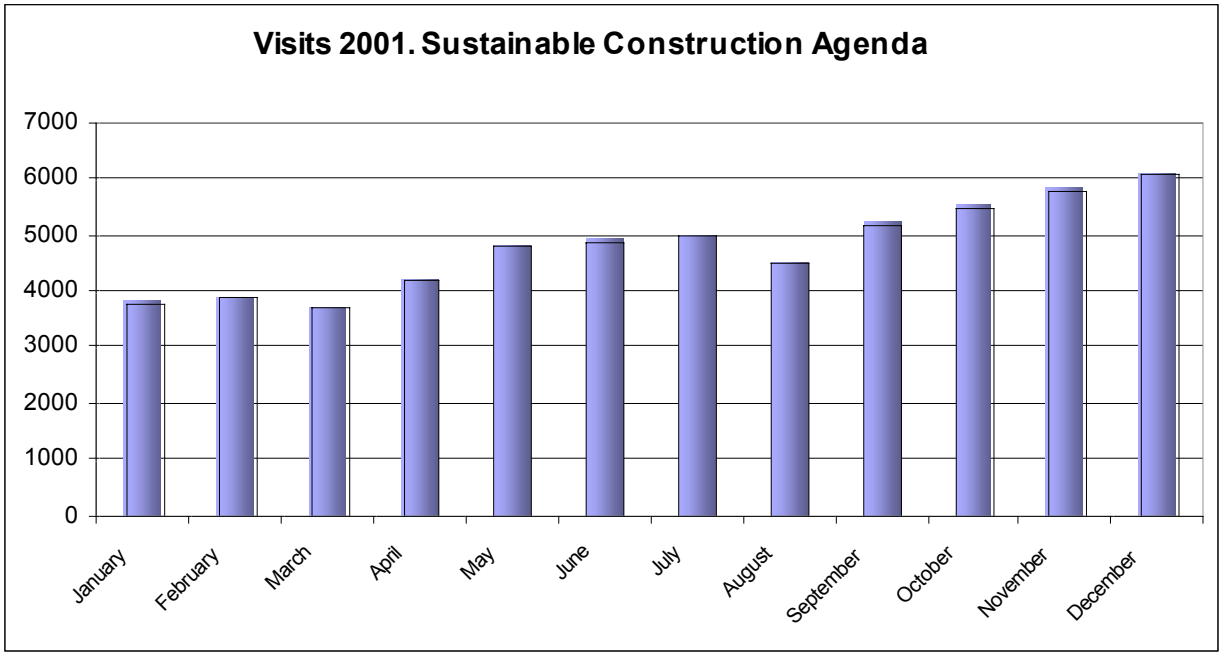
  Nowadays, we can find a certain quantity of buildings and urban interventions with sustainable criteria in his design and construction. In this section are collected systematically some of these interventions. The database, consists of a relation and graphic documentation of projects, buildings and other actions. This is one of the most visited sections of our web site

- ***Professionals***

  In this section, you can access to the different agents involved in construction: architects, engineers, enterprises an so on.

3. RESULTS, THE FUTURE

With the results obtained to the moment, we believe to have come to obtain a product that begins to fill all the expectations that had to the start of this project in which refers to the organization and the type of information that believe that should have in a web site as this. The fact of having reached the amount of 6000 visits/month (see graph), shows us that we are filling an space that is requested by the market



That's why for the future our objective is to maintain the actual proposal, and to continue giving a most consistent content to the 8 monograph sections. So our operative objectives for the next year would be:

- To continue with the investigation and the analysis again actions and buildings that have introduced Good Environmental Practices, in order to increase the Good Practices Database.

- Graphic improvement of the presentation and of quality of the contents of the registers of the Products database, businesses and legislation, and to continue the constant search of products.

- To create diverse forms to facilitate the work of communication of the users with the web, so that they can propose information to insert in it.

- To involve the major possible number of companies and associations related to the construction and environment in our project, so that the message of the *Agenda* arrives at the most maximum possible number of users, and at the same time to make that the information we elaborates and publish be of the maximum present time and reliable.

4. CONCLUSIONS

During the 2001 year, we have attended progressively to the media environmentalisation of our sector, and almost can be affirmed that there has been no publication of construction and architecture that in the course of this year has not tried in some occasion of themes related to the environment, also we have attended the implementation of the Solar Ordinance of Barcelona and to the each more growing time number of aids given by the city Halls to this type of installations. Also it is to emphasize the new aid upon the tax of constructions approved recently in Tarragona according to the environmental improvements introduced in the projects. All these facts indicate us that, little by little, the environmental conscience of the different agents goes changing, what would be able to do to suppose, seen since a proper point of view absolutely partial, that the message we are divulging begins to give its fruits.

On the other hand, not one must forget that the attainment of the general objectives of the project are even far away, and that still one must fight a great deal to arrive at the totality of these agents, since promoters to users passing for the political class, the technicians, the constructors and the industrials of the sector and the manufacturers of materials.

From our web site, we've seen growing month by month the number of visits till 6000, quantity that, for a such concrete theme, and for a so small geographic area is so great. Furthermore, the number of subscriptors of our newsletter is growing too, and has doubled since last year. This two quantities, make us happy about what we have reached and stimulates us to work harder. We are working on expand our influence area, and that's why we are working in the international diffusion, to make our project to be known all round with the final objective of creating an international network

To sum up, the attainment of this goals makes us optimist for the future and animates us to continue working in this line to gain the sector environmental sensibilization in order to reduce the final impact of our sector.

Sustainable Transformation of an Urban Settlement System; Gdańsk Agglomeration Case Study

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1. INTRODUCTION

The coastal Agglomeration of Gdańsk, consisting primarily of three major towns, Gdańsk, Sopot and Gdynia, is the core of subregional settlement system, bringing potential metropolitan area (Figure 1) into functional, spatial, economical and socio-demographical interrelations. These links, concerning particularly relationship between residential areas, jobs, services and recreation facilities, are illustrated by the fact that, despite demographic stagnation of urban areas, the overall population of the subregional system is growing. The strongest relations link the Agglomeration with 17 neighbouring townships and rural communities. In 2000-2001 the S*trategy Plan of the Sustainable Structure of the Three-City Agglomeration* (Baranowski et al.) was elaborated, covering the 17 communities' area of 1.700 km^2 with the population exceeding 970.000 inhabitants. The aim of the plan was to work out a concept of planning and managing transformation of the Agglomeration's spatial structures according to the principles of sustainable development.



Figure 1 Settlement systems of Poland's coastal regions.

2. PROBLEMS AND CONSTRAINTS

The research work indicated that planning sustainable Agglomeration structure is challenged by a number of unsustainable development factors:

- Uncontrolled process of extensive settlement system development, leading to suburbanization and counterurbanization (migration to surrounding small townships), characterised by chaotic development of shapeless, inefficient structures and by their negative environmental impact;
- Passive, reactive land use policy characterised by sectoral, short-term approach to solving spatial problems, ignoring environmental costs;
- Growing external and internal development disproportions [a] between major urban centres and neighbouring communities and [b] between specific areas within urban centres, concerning access to public transport, services, and infrastructure;

- Frequent spatial conflicts and competition between local governments, leading to disintegration of the Agglomeration structures and transport system, lower rationality and reliability of the decision making process;
- Excessive concentrations of jobs and monofunctionality of many urban structures increasing travelling; declining socio-cultural identity of urban structures; socio-cultural, economical, technical and spatial degradation of numerous areas;

The Agglomeration is facing the following constraints for its sustainable transformation:

- Degraded urbanized areas (residential, green and industrial areas, brownfields and ineffective technical systems) which [a] worsen living conditions, [b] increase future environmental costs and renewal expenditures, [c] affect tourism and investment attractiveness of degraded and adjacent areas.
- Suburbanization zones; chaotic, shapeless development of housing, production and services, coinciding with decreasing agricultural land use may lead – if peripheral zones continue to attract investment - to decay of central areas.
- Large monofunctional residential districts; housing blocks from 60'-80' period with insufficient services and jobs, substandard public spaces, which require complex revitalization programmes (including saving energy and resources projects).
- Concentrations of jobs; two large concentrations of shipyards, co-operating industries, harbours and transport infrastructure in Gdańsk and Gdynia generate excessive transportation demand; monofunctionality may lead to ineffective use of space and of technical infrastructure and to high restructuring costs of the market sensitive industries.
- Monofunctional concentrations of services; the policy of locating large commercial centres on the outskirts of the urbanized areas create excessive transportation demand.
- Tourism and recreation; the lack of integrated organization, management and marketing of the tourist & recreation business leads to uncontrolled development of incidental and too often substandard services and land use; large concentrations of allotment gardens and summer houses threaten the environment and landscape.
- Public spaces; the problem concerns poor quality of many urban structures, deprived of spatial and socio-cultural identity with negative social effects.
- Transportation system; [a] heavy traffic transit roads and railways cut across the central areas of the Agglomeration; [b] difficult access to the harbour areas; [c] excessive transportation demand resulting from monofunctionality of many urban structures; [d] exhausted capacity of many crossroads and traffic congestion; [e] lack of integrated metropolitan transportation system and decline of public transport.

3. SUSTAINABILITY GOALS AND PRINCIPLES

3.1. Goals.

The goals of the plan have been formulated as follows: [a] preventing further disintegration and growing unsustainability of the Agglomeration structures; [b] creating environmental, socio-cultural, spatial and technical conditions for sustainable development of the Agglomeration; [c] formulating guidelines for transformation of the Agglomeration structures; [d] complying with the standards of Local Agenda 21', European Union and of the Sustainable Cities organization. For the transportation system development the following goals have been recommended: [a] restricting general transportation demand; [b] improving quality of public transport and reversing its further decline; [c] improving traffic safety; [d] improving efficiency of the road system, particularly in the congested central areas; [e] reducing negative transport impact on living conditions; [f] improving transport of goods and [g] developing the metropolitan system of integrated transport planning and management.

3.2. Sustainability principles.

It is particularly important to improve the effective use of the Agglomeration central areas, differentiated in their density. According to the general principles of intensifying the space use, increasing multifunctionality and reduction of transport demand, following land use policy has been recommended:

- Creating multimodal transport intersections attracting functions which are clustering the trip ends; priority for public transport;
- Restricting car parking in the central areas;
- Intensifying land use around transport intersections;
- Encouraging the development of the Agglomeration structure based on the concept of *decentralized concentration* (Owens, 1986, *SPESP* 2000).

The relation between residential areas, work and services must be planned according to the criterion of the reduction of transport demand, which implies [a] sustainable revitalization of the existing residential districts (intensification of the land use, multifunctionality), [b] priority for new housing developments on inner urban waste lands; the following measures have been recommended:

- Priority for activating urban inner areas (transformation, revitalization, intensification);
- Departure from the model of monofunctional residential districts to multifunctional mixed land use (housing, jobs, services), aiming at reduction of the transportation demand;
- Revitalization programmes for existing housing structures must take into consideration improving living conditions, social programmes and protection of cultural identity, reduction of environmental impact (saving energy and resources programmes).
- New housing development projects must observe European environmental standards; it is necessary to elaborate preference system, encouraging environmentally friendly design methods, technologies, maintenance and recycling building substance (life-cycle assessment, environmental preference method).

The system of green areas, and of the Agglomeration ecological structure should be planned according to the following principles:

- Planning green areas and corridors as continuous system of the Agglomeration structure;
- Linking urban system of green with the countryside in form of the rural parks extending the area of the Three-City Landscape Park to the South;
- Reclamation of brownfields for urban green areas;
- Encouraging initiatives of local communities to create small green and water structures.

Growing tourist function must be given particular attention as promising development factor for Agglomeration's economy. The following principles have been recommended:

- An integrated metropolitan programme for the development of tourism and recreation, co-ordinated in regional scale, must be elaborated; the programme should reverse chaotic development of tourism and offer integrated planning, organization, providing technical infrastructure and management of places and areas of interest;
- Spatial policy and land use must be aimed at reducing impact of mass tourism and recreation on environmentally sensitive areas (coastal zone and Three-City Landscape Park) by creating buffer network of recreation parks;
- The programme for increasing environmental awareness and encouraging environmentally friendly recreational activities and eco-tourism should be implemented; it is also recommended to lessen tourism seasonality by developing business & cultural tourism.

Suburbanization processes and structures of the peripheral areas of the Agglomeration require thorough comparative analysis of their economical, social and environmental efficiency. The subject of the comparison should be [a] priority for territorial expansion or [b] priority for transformation and intensification of the existing urban structures; efficiency of centralised

technical infrastructure systems (heat supply and sewage discharge) must be analysed. The following policy has been recommended:

- Preventing uncontrolled, dispersed new urban development, lacking access to transportation system and to basic technical infrastructure, is of utmost importance;
- Suburbanization areas should be planned as multifunctional zones of interacting structures of built and natural environment;
- Corridors of the Agglomeration ecological structure should be linked with surrounding rural areas and provided with recreational facilities reducing the penetration of the protected areas;
- New residential developments should be designed in the form of ecological settlements, encouraging the use of alternative technologies (energy supply and sewage discharge) and saving energy and resources measures.

4. THE AGGLOMERATION'S SYSTEMS

Planning sustainable structure implies cross-sectoral system approach. In case of the Three-City Agglomeration following systems play important role:

1. *Natural environment system*; determining opportunities and development options, however, damaging its self-regulatory resistance potential may exhaust its resource potential, threatening not only development but even functioning of the system.
2. *Environmental infrastructure system*; its aim is to reduce impact on the environment by means of technologies (saving resources, utilization and recycling) and of socio-cultural policy (changing consumption models, fiscal and economical policy)
3. *Settlement system*; its efficiency depends on [a] relations „home – work – services – recreation" important for its integration and [b] relations „natural environment – built environment".
4. *Transportation system*; its role is not only to answer to the transportation demand created by the above-mentioned relations, but also to model (reduce) transportation needs.
5. *Coastal zone system*; grouping sea-related functions and activities and determining to a great extent the Agglomeration's structure and development potential.
6. *Tourism & recreation system*; its growing economical importance provokes discussion on general model of tourism & recreation; more attention should be paid to eco-tourism, cultural and business tourism.
7. *Technical systems*; their main task is not only to supply the needs, but also to save resources and to reduce pollution loads.
8. *Cultural system*; it plays the role of quality indicator for urban structures in the spheres of [a] protection and promotion of cultural heritage and [b] creating spatial and social identity of new urban structures.

The environmental, spatial and socio-economical differentiation of the Agglomeration structures requires using in each case different tools for increasing their sustainability. These spatial differences have been identified in the form of *operational zones* (Figure 2); for each zone the recommended policies and actions have been formulated:

I. *Coastal zone* of the Gdańsk Bay, Gdańsk and Gdynia harbours and of the Dead Vistula and Motława rivers; priority for the sea-related functions (harbours, shipyards, recreation and health resort functions); integrated planning in the scale of Agglomeration; creating and protecting identity of the coastal structures (waterfronts, landscape values).

II. *Dense urbanization zone*; development of the main centres of the polycentric settlement system together with integration nodes (intersections) of multimodal public transport; deconcentration of jobs; increasing multifunctionality of urban structures; transformation and restructuring of former industrial areas and waste lands; protection of the cultural

heritage and urban landscapes; planning the Agglomeration ecological structure on the base of the continuous green areas system.

III. *Metropolitan recreational park zone*; planning of the Three-City Landscape Park and its protection zone for recreation, based on differentiated land use intensity and on controlled accessibility to protected areas.

IV. *Suburbanization zone*; restricting chaotic investment; integrated policy of grouping investment in potential centres; planning cluster settlement structures integrated with the development of social and technical infrastructure; ecological settlements serviced by local alternative technical systems; creating Metropolitan Science & Technology Park.

V. *Countryside agricultural & recreational park zone*; policy of encouraging the development of new counterurbanization centres and of grouping new investment in strictly demarcated zones; protection of the regional environmental structures; creating buffer system of metropolitan recreation parks; protection of rural landscape; promoting ecological farming.

VI. *Agricultural landscape zone of Żuławy*; priority for agriculture; restricting expansion of urban development; closing down the industrial landfills; protection of the unique rural landscape.

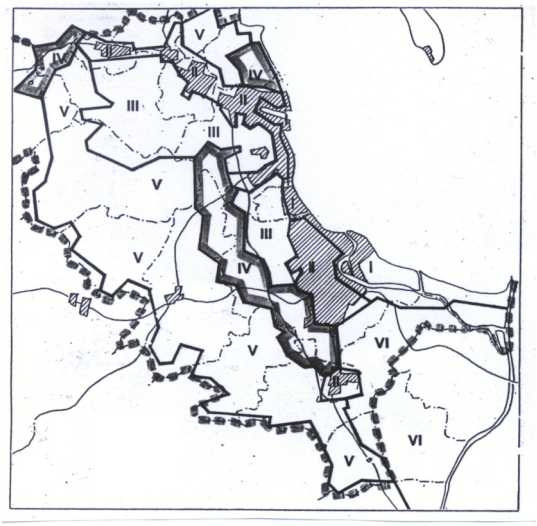


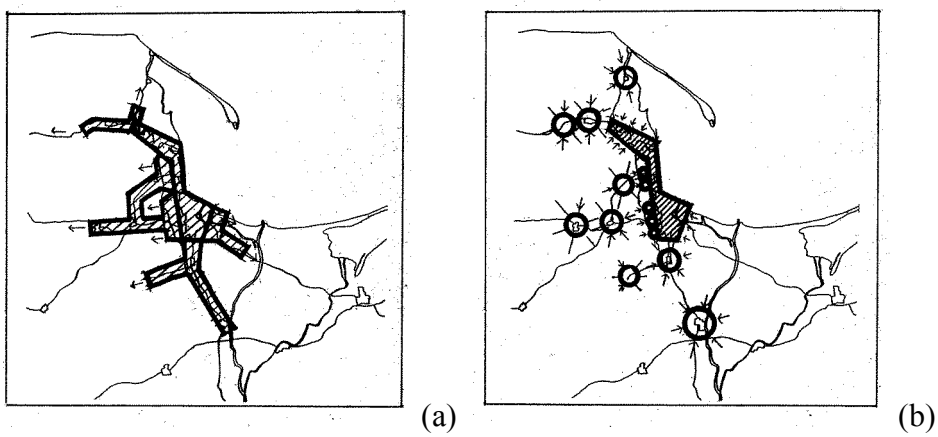
Figure 2 Suburbanization zones of the Gdańsk Agglomeration

5. CONCLUSION

In case of the Gdańsk Agglomeration the urgent need for housing and for new jobs must be seen as an additional sustainability factor for „towns – rural areas" and „towns – towns" relations, requiring co-ordination on local, subregional and regional level. *The Agglomeration's development implies choosing between [a] further development of the main centres, absorbing growing migration and [b] improving accessibility of neighbouring areas from Agglomeration, stimulating development of the settlement system based on counterurbanization centres, linked with the Agglomeration's core area by effective public transport system*.

Environmental and technical thresholds limit further development of the Gdańsk Agglomeration as a continuous spatial structure. *The alternative solution for its sustainable development can be described as a model of counterurbanization (discontinuous structure of decentralized concentrations)*, evolving towards metropolitan settlement system (Figure 3). The main sustainability factors are [a] integration of the management of the metropolitan settlement system, [b] managing the relation „home – work – services – recreation" and the transportation system with regard to the criterion of reducing demand for travelling, [c]

increasing multifunctionality of urban structures and [d] modernization and development of the technical systems based on the principle of saving resources.



(a) (b)

Figure 3 Models of the Gdańsk Agglomeration's settlement system: (a) suburbanization model, (b) counterurbanization model.

A number of interrelated implementation methods and tools has been recommended, comprising corporate approach, training local governments administration staff, auditing and sustainability indicators, trade standards, public participation and creating mechanisms of integrated management of the metropolitan settlement system. However, t*he most important conclusion is that elaborating the organizational scheme of co-operation and co-ordination of decisions on metropolitan level must be seen as precondition for efficient sustainable structures development.* It is recommended, that this proposal should be substantiated in the form of an institutionalised *Metropolitan Agreement* based on the concept of *rural-urban partnership.* Within this agreement involved partners, i.e. local governments and administration, business, public sector and non-government organizations commit themselves to co-operate on the development of an integrated sustainable settlement system (examples: Munich and Lyon metropolitan areas).

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Learning from the Past: an Example of sustainable urban Settlement in the second post-war Period in Turin (Italy)

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1. INTRODUCTION (M.M.)

1.1 The INA-Casa Plan

Hammered by Allied bombing, Italy's major cities were faced with an urgent housing problem at the end of the Second World War. On February 24, 1949, the Italian Parliament approved a wide-ranging bill drafted by the Minister of Labor and social security Amintore Fanfani which was designed to boost employment in the construction industry by providing incentives to build working-class housing. The construction industry, in fact, was regarded as the sector which was best able to act as the driving force behind the country's economic recovery. The new law established that the initiative would be financed using a mixed approach, with funding from the government, employers, and monthly withholdings on employee salaries. Thus was born the INA- Casa Plan, one of the most extensive and significant of Italy's endeavors to plan, implement and manage socially motivated construction. It had a major impact on post-war reconstruction in the sector, not so much for the sheer number of buildings produced, but because of the quality of its achievements in architecture and urban planning, its geographical coverage, and the enormous mobilization of cultural and professional resources it involved. [1]

1.2 Cultural background and goals of a fully cognizant experiment

The INA-Casa Plan can be seen as a grand experiment which, through its emphasis on local materials, rural building types and pre-industrial technologies, pursued new housing models of broad cultural import. This experiment was conducted with a minimum of fanfare by a class of professionals who contributed, at least in their intentions, to the country's modernization through rebuilding and renewal.

The entire operation represents an attempt to give concrete form to the concepts of the city that had been ripening since the late nineteenth century in the English-speaking countries and had later been taken up in Northern Europe: concepts that were to recast the life and the private and shared spaces of entire urban communities in a new social mold. What we see in post-war Italy is an a effort to import the Northern European model, based on the organic, self-sufficient neighborhood. In this model, the neighborhood is seen as a unitary structure, based on clear-cut relationships between the number of inhabitants and the services it offers, in accordance with a modern view of the community. In planning such a neighborhood, the role assigned to the layout and design of shared open spaces is of crucial importance: paradoxically, it is precisely the unbuilt space which gives structure to the entire urban residential unit.

The INA-Casa Plan administration promoted the general adoption of a uniform and credible quality standard, employing a regulatory strategy based on manuals with examples of construction practices and performance requirements. The decision to use a relatively weak regulatory approach had important repercussions on method: each designer was obliged to interpret these guidelines on a case-by-case basis, finding the solution which was most consistent with the local context and local needs. Today, re-reading the material achievements made in the 14-year course of the Plan in the light of our contemporary concerns with sustainable construction reveals just how important this work can be as a potential resource in the development of our cities, and underscores the need for effective guardianship. Such, indeed, are the conclusions that emerge from a national research program involving a number of researchers[2] which addressed modern construction in Italy and the heritage left by the INA-Casa Plan between 1949 and 1963 in particular.

Focusing attention on the city of Turin, we find that government participation played a central role in local building policy during post-war reconstruction, as it ensured competent work, expeditiously performed. Prominent among the pilot projects embarked on in this period was the *La Falchera* initiative, so called after the district of that name. The complex was designed by such mainstays of the Modern Movement in Italy as Giovanni Astengo and Mario Passanti, as well as Gino Becker, Nello Renacco, Ettore Sottsass and Paolo Perona. One of the most important figures for the Turin project was Giovanni Astengo, who together with Renacco, Aldo Rizzotti and Mario Bianco drew up the first Regional Development Scheme for Piedmont immediately after the war. Turin joined – and indeed outdid – many other centers in putting up a sort of mute opposition to the International Style, which took the form of an increasing attention to the urban environment, to the site, and to existing work and the cultural phenomena from which it springs: an attention informed by a view of modernity that founds itself in a return to the best national and local traditions.

2. LA FALCHERA: A PIONEERING EXAMPLE OF EXPERIMENTATION IN URBAN PLANNING AND PRECURSOR OF "GLOCAL SUSTAINABLE" CONSTRUCTION (C.M.)

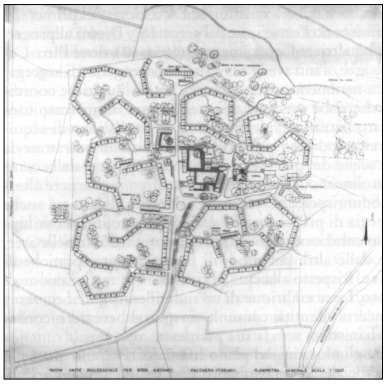
Example of an experiment of enormous architectural and cultural merits, La Falchera fell short of winning the complete acceptance of its contemporaries. Today, however, the complex is of compelling interest because of the values it embodies, and not simply as a group of buildings.

In the debate now centering on sustainable construction, it is important that we not remain embroiled in the purely technological aspects of construction (i.e., the building techniques and materials used), but also remember the environmental and compositional issues involved in the built complex, as well as the human and social values that it expresses. With its extensive garden areas in each housing block, its individual dwelling units pivoting off spacious porticoed terraces oriented favorably with respect to sunlight and prevailing winds, and its way of handling space and movement to satisfy the needs of the community, the La Falchera complex in Turin can be regarded as a model of urban design which is in all respects "sustainable", and hence as a possible starting point for our reflections on a new and more attentive approach to construction.

Built as part of the INA-Casa Plan (1949-1963), Turin's La Falchera project stems from a singular attention to the social, economic and environmental implications of the dwelling-place. The feature that most clearly sets this neighborhood (and its coevals elsewhere in Italy) apart from the later urban outgrowths that surround it (the original core of the project was

built in the first half of the ’50s on a large tract north of the metropolitan area) is its handling of “open” space; here, in fact, the dwelling-place is no longer just the area surrounding each individual unit, but the whole space implicit in the idea of a self-sufficient residential unit, including interior and exterior, domestic and urban.

In this connection, Arnaldo Foschini, a leading figure in the cultural and political life of the day and a prime mover in initiating and managing the INA-Casa Plan, wrote: “…one of the things we must do is to handle each area and space in a way that ensures the designer’s economic concerns are kept from view, and which at the same time succeeds in making the home cheerful and welcoming as well as perfectly functional. Finally, the complexes we build must contribute to achieving that architectural and urban harmony that has always been our country’s boast in past centuries, when the monumental and the minor, the proud city and the small town, received the same unstinting attention.”[3] And for his part, Giovanni Astengo, urban planning supervisor for La Falchera, wrote “A housing development, a neighborhood, an independent residential unit are much more than simply the sum of their parts: they are social units, where the life of the individual, the family and the group can take place with





fewer constraints, fewer burdens and more freedom – in short, be richer – than in the impersonal metropolis. But achieving this calls for town planning that is not just lines on paper, but results from coherent social thinking. The examples of the English garden cities, the American greenbelts and Sweden’s planned quarters are concrete demonstrations that these new social units are far from merely Utopian”.[4]

Figure 1 Layout drawing (1956) and one of the ceramic tiles marking the entrances to the dwelling units.

In this, as in other statements made by Astengo, we can detect a number of elements that can be regarded as precursors of today’s sensitivity to sustainable construction and environmental sustainability in general: the perceived need to build residential complexes where aesthetic, functional and environmental values can coexist in harmony, and the attention to the quality of life, an attention centering more on satisfying individual and social needs than on complying with cut-and-dried planning standards. Thanks to the INA-Casa Plan, thousands of Italian families were able to improve their living conditions. The vast majority of these people could thus move away from shared housing, overcrowding (with as many as 1.86 - 2 persons per room, according to the 1951 census), or improvised accommodation in shanties, cellars, etc.[5]

As regards “qualitative” design issues, La Falchera and the other products of the INA-Casa Plan built in the same period embodied a number of significant elements that were codified in

a series of publications whose purpose was to specify "guidelines" for housing project design.[6]

According to these guidelines, compositions were to be "varied, animated and well articulated, capable of creating restful and welcoming surroundings with differing views on all sides and attractive vegetation", while each building should have "its own distinct physiognomy, so that each resident can find his own home with ease and sense that his personality is reflected in it".[7] In addition, the house should contribute to "the formation of an urban environment, with full consideration for spiritual and material needs: not the material and spiritual needs of mankind in the abstract, but those of real living beings, people who neither like nor comprehend the monotony of identical and endlessly repeated houses, where the only thing that distinguishes one house from another is its number; people who do not want to live locked in a rigid grid like pawns on a chessboard, but who want their surroundings to be both tranquil and varied. It will thus be the lay of the land, its exposure to sunlight, the scenery, the vegetation, existing buildings and the sense of color to suggest how new urban developments should be laid out so that their inhabitants can feel that there is something spontaneous and genuine in them, something indissolubly linked to the ground from which they spring."[8]

The recommendations concern the two-fold issue of achieving modernization while at the same time preserving local tradition, a heading that includes lifestyles, climate, construction materials, building methods and skills, and the type of heating systems to be used. The new neighborhoods were thus required to adapt to the existing setting, eschewing any tendency towards standardization or mass production. Consequently, prefabrication was rejected as contrary to the plan's primary goals, which on the one hand sought to bolster employment among the various categories of workers and professionals in the construction industry, and on the other hand strove to promote the design of new buildings consonant with the natural, architectural and social environment surrounding them.

Today, this approach to new building could be called *"glocal"*, as it fosters a renewal of the ways we build which is at once far-reaching and sustainable, as it is based on close attention to the site in terms both of the materials and techniques used, and in its furtherance of specific human and environmental values. At La Falchera, as Astengo affirmed in a study published in *Metron Architettura* (1954, No. 53-54), "psychological considerations dictated that we reject building types which are strictly associated with the city, such as free-standing blocks or high-rise housing, as well as those such as row houses with individual gardens that are characteristic of the "siedlungen", since both are inappropriate for the type of resident. The area itself suggested that the designers opt for medium-high buildings which gave a "city" feel without cutting residents off from the country air that filled the lungs just on the other side of the Stura river. […] Across the meadows edging the project, the eye ranged unimpeded to the Alps, the hills, Superga and the woods. It was imperative that these sweeping views be preserved as part of the neighborhood. There, the chaotic fringes of the city were far away, masked by the thick blanket of multicolored fumes belching forth from factory smokestacks. And this distance must be maintained, as what was needed here was the sensation of another type of city, another way of life. The idea of the three-storey buildings surrounded by broad green areas was conceived, as it were, on-site, looking at the landscape and the countryside, and contemplating the surrounding rural settlements, with the big, U-shaped farmhouses spreading their arms southward, of which the outbuildings of Stupinigi were the most conspicuous example".[9]



We can thus say that today, in our attempts to redefine and redesign new patterns for living that are sustainable in the broadest sense of the term – humanly, socially, architecturally and environmentally – projects such as La Falchera in Turin can still serve as a model.

3. CONCLUSIONS. FROM THE CONCEPT OF "RESPONSIBLE DESIGN" TO THAT OF "SUSTAINABLE ARCHITECTURE" (C.C.)

The need to enhance and safeguard La Falchera is widely recognized today, not just in the cultural milieu that gave life to the research program, but also among a significant portion of the neighborhood's current residents, many of whom still have links with the original beneficiaries of the project.

Figure 2 General and detail views of several dwelling units.

Many of the principles that are now acknowledged as underpinning the concept of "Sustainable architecture" and which inspired what was then called "responsible design" emerged, almost of their own accord, from this research. The Master Plan for the project, coordinated by Giovanni Astengo, provided working guidelines for each lot which were extremely precise and straightforward, but also allowed designers considerable scope to express their own individuality. The Master Plan devoted particular care to the buildings' orientation and exposure in order to make the best use of solar energy, which even then was considered in terms of both heat and light. Carefully distributed interior spaces made it possible to organize the buildings into homogeneous blocks, mostly featuring "three splayed wings" which were differently oriented to give the complex its distinguishing character. The space in front of the buildings was thus contained but not enclosed, giving each block its own green area.

The Plan's designers steeped themselves in the studies of residential building orientation then being produced, convinced of the need to develop codified criteria for establishing acceptable levels of sunlight exposure which could be used in assessing the construction potential of a building lot[10]. At the same time, these studies aimed at making the best use of available ground, and were based on identifying the relationships between building height and spacing with varying placement which would ensure that every habitable room in the house would receive a certain minimum hours of sunlight, every day of the year. According to the site's latitude, graphical procedures made it possible to check that "on the day of the winter solstice, each of the said rooms is directly and consecutively exposed to sunlight for at least two hours, preferable beginning one hour before noon and continuing for the entire hour thereafter", starting from the lowermost storey in the building. These studies, which were applied in drawing up the master plan for La Falchera, also served as the basis for building regulations and influenced the approach taken in the urban planning laws of the day. The

guidelines expressed in the master plan also called for technologies and materials – such as exposed brick masonry – that were traditionally used in the surrounding rural areas, and thus made it possible to employ local labor in compliance with the social objectives set out in the current scheme to provide more jobs for manual workers, the *Piano per l'incremento dell'occupazione operaia*.

The distribution of interior space in the buildings, which were organized in three levels, was based on the type of residents for whom the project was intended and their need to find housing after the turmoils of the war. Each apartment had windows on opposite sides of the building, with kitchens and bathrooms giving onto loggias. The orientation and sizing of these loggias, as well as their usability, comply with the bio-climatic criteria which are now seen as necessary to a sustainable architecture rooted in the rational use of natural resources. Though rooms are sized on the basis of minimum standards, public spaces and buildings are provided for social and community activities.

To the modern eye, the objectives of the La Falchera master plan project clearly include those of optimizing human resources, materials and energy usage: goals that are typical of a type of "cognizant" design which we would now call "sustainable". Likewise, the architectural products that derive from it were, and continue to be, excellent.
The current level of decay, which is all too apparent after some fifty years of life, are in no way to be blamed on general design decisions. In some cases this decay is the result of workmanship which was not always of the best; in others, it is the consequence of the uncontrolled and independent conversions that took place over the years as the type of resident changed and expectations evolved. Most of the loggias have been walled-in, and thus no longer provide their bio-climatic advantages, while ownership of the buildings has been transferred from the public administration to private individuals.
As we interview the residents today, however, we can clearly see their perception, perhaps unconscious, of the complex's inherent merits in terms of sustainability: a perception which can be recognized in the amount of care and maintenance lavished on the buildings and common spaces. Many people are now choosing to live in La Falchera, or are moving back to it, seeing it as an ideal place to live, far from urban areas that have long since become unsustainable. These merits make it incumbent upon us to do everything we can to protect and safeguard the many such neighborhoods built during the period in Italy.

Notes:
[1] For a complete coverage of the INA-Casa Plan, see Paola DI BIAGI (ed.), *La grande ricostruzione. Il piano INA-Casa e l'Italia degli anni '50*, Donzelli Editore, Rome, 2001.
[2] Participants in the MURST program *"Gli interventi INA-Casa in Piemonte: declinazioni morfologiche e tecnologiche in ambito urbano e extraurbano - L'ambito urbano: Torino quartiere Falchera"* included P.G. Bardelli, C. Caldera, E. Filippi, M. Mangosio, C. Mele, R. Morganti, C. Ostorero and P. Paintanida.
[3] "Piano Marshall", October 23, 1949, quoted in P.DI BIAGI, op.cit., page 14.
[4] G. ASTENGO, *Nuovi quartieri in Italia,* in "urbanistica", 1951, No. 7, pp. 9-10.
[5] See P.DI BIAGI, op.cit., pp. 18-19
[6] Piano incremento occupazione operaia, *Suggerimenti, norme e schemi per la elaborazione dei progetti,* fasc.1 e 2, Rome 1949 – 1950; A. LIBERA, *La scala del quartiere residenziale,* Rome, 1952
[7] Piano incremento occupazione operaia. Case per lavoratori, 2 *Suggerimenti, esempi e norme per la progettazione urbanistica. Progetti tipo,* Rome 1950, page 7.
[8] Ibid., page 8.
[9] G. ASTENGO, *Il quartiere Falchera, Torino,* Metron Architettura No. 53-54, 1954, p.20.
[10] See the article: "Sul soleggiamento degli edifici di abitazione", by Giovanni Astengo and Mario Bianco in Metron, No. 9, 1950, Editrice Sandron, Rome.

High life in low energy houses

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It is a common belief that reduced costs is the main motivator to make people interested in energy efficiency. If this were correct, the acquisition of a low energy house would reflect a long-term interest in saving money. This paper analysis such motivating factors as well as the way low energy houses may be appropriated by users/owners. The appropriation of new technologies involves presumes that the technology is adjusted to users' everyday life, and the other way around. Thus, the outcome of efforts to appropriate a low energy house is uncertain. We know from previous studies that cultural factors are as important as technical qualities in determining the consumption of energy of a given house (Aune 1998). This means that we need to know more about the way that low energy houses are being used in order to assess the impact of such technologies.

In this paper I will present some results from a case-study of the way end-users adapt to and adopt low energy houses in a small co-operative. Why did they choose to buy such a house, what kind of meaning do they attribute to their home, how do they live there, and how do they learn to use this new and unknown technology?

APPROPRIATING NEW TECHNOLOGIES: THE DOMESTICATION MODEL

The domestication model represents a particular theory of the way new technologies are appropriated by users (Lie & Sørensen 1996). It provides tools for analysing users and their interaction with technologies that are supposed to be integrated in a particular setting, like the home. To domesticate an artefact, object or technology involves negotiation about its meaning and way of use. Thus, the domestication of an artefact or technology is a to-way process, where the artefact as well as the user is reshaped.

According to Sørensen (1996) strategies of domestication involve three main dimensions: practical, symbolic and cognitive. In the practical dimension domestication brings forward a pattern of usage. How is the artefact employed? The symbolic aspect is about production of meaning, and the relationship between meaning, identity and the public presentation of self. The cognitive dimension refers to need to learn how to operate and employ a new artefact. According to Sørensen (ibid.) domestication is a fruitful focus because through the study of domestication become sensitive to the construction and reconstruction of culture as combinations of old and new artefacts, skills, knowledge, and social relations into a seamless web of small sosiotechnical systems.

A previous study of implementation and use of waterbased floorheating in private houses showed that the end-users experienced the domestication of the technology as a difficult and complicated process (Kongsli 2001). The study demonstrated, not surprisingly, that the end-users that had no technical interest or technical education found it difficult to learn about the new technology as well as use it. The technically interested on the other hand had chosen to

have waterbased floorheating and they had been a part of the whole implementation process. When it came to learning how to operate the system, the technically interested were relatively more conversant with it than most other people.

Berg (1996) has identified a slightly different problem. She found in her study of design of smart-houses that the designers of these houses addressed end-users that shared the producer's fascination with electronic and technical gadgets. The target-consumer for the smart-house was a technically interested man, thus the design was adapted to a technically interested and competent audience. If the design of low energy houses follow a similar pattern, we would expect either to find that buyers have a special technical interest or that they have serious problems in domesticating the technology that supplies the houses with heat.

METHODOLOGY AND DATA MATERIAL

This paper is based on a case study of a housing co-operative with low energy houses located in a small town in Norway. Data for this case study have been collected through interviews and documents. I have conducted four interviews with owners/users in the co-operative, which consists of 13 units. The interviews took place in the house. In that way I had a chance to feel their indoor temperature and see the technology. The users were also able to demonstrate how they used the technology as well as to show me other things they wanted me see or thought I might be interested in. This explorative approach is especially suitable in trying to grasp the symbolic dimension of the domestication process.

In addition to this I have used written sources. Brochures, press clippings and similar material have been employed to get a broader picture and more information about the co-operative and the low energy houses.

The houses in the co-operative have waterbased floorheating. The water circulating in the waterbased floorheating uses heat, which is collected via antifreeze solution, from the sea near by. A shared heatpump is elevating the temperature on the water from the sea up to 35-50 degrees Celsius. When the water is hot enough it is distributed to the houses, and inside each house the water is distributed according to the setting/adjustment in the different houses. In addition each house have a heat recovery unit.

Because of some problems with the system, the distribution of heat (hot water) to some of the houses had been uneven, and as a result some of the houses use more energy than others do. All the houses had installed an energy meter measuring the energy-use, but due to the technical problems the co-operative decided not to use them. Instead each household had to pay a fixed amount every month. The amount was calculated according to the size of the various houses.

MOTIVATION AND MEANING

The houses in the co-operative were marketed as sustainable when the housing co-operative began to sell them in the spring of 1998. According to the person in charge of this project the housing co-operative had no problem in selling the houses. Was it then the low energy, environmentally friendly, aspect that motivated the end-users to buy a house in the co-operative?

All the end-users I talked to said that their prime motivation to buy was *the location* of the houses. The housing area was situated close to the city centre, only a 10 minutes walk away,

yet sort of secluded with a small but nice recreation area nearby. The sea was even closer and easy accessible.

Non of the end-users said that the alternative, more sustainable heating system was of vital importance. The alternative heating system made the houses even more attractive, said two neighbours, both engineers, but it was not their main motivation to buy. Other end-users in the co-operative, like a woman in her late fifties, without any technical education, said the same. She had not even heard about that kind of heating technology before she attended the information meeting, but she thought it sounded pleasant and comfortable and therefore she was positive. She told me that she at first had been a bit sceptical; would it work? But she soon decided to trust the engineers who said it was reliable.

To summarise, none of the users made their decision to buy a house one the basis of a particular interest in the heating system. They described themselves as environmentally conscious, but none were active in any environmental organisation. It is interesting to note that none of the users was *negative* to the heating system and the low energy concept. They all accepted it and they never thought about trying to replace the system. This may imply that users/homeowners actually are quite flexible and receptive to new technological solutions to supply heat and warm water. Thus, if the house for various other reasons is attractive the end-users seem to accept the alternative heating system fairly easy.

In fact, even though my informants had experienced technical problems and rent increase as a result of these problems, they still talked about the low energy houses in a positive way. The users said they enjoyed talking about their home and the innovative heating systems, and that they quite often discussed the system with friends and acquaintances. My informants said that they almost always chose to focus on the positive experiences. They told it was warm and comfortable, easy to use, reliable, etc. They also expressed that they from now on could not see themselves living in a house *without* similar energy technology. One user described other energy sources as " old-fashioned". Another user said other energy sources were to "messy" and "bothersome".

They also informed me about an environmental prize that the co-operative had won, and that they were the destination of excursions and guided tours to the low energy house co-operative to look at the heating systems. According to Gullestad (1989) a home is not just a place we live, but a condensed symbol for many of the things that are important for the people who live there. Clearly, the houseowners were quite proud of their houses and the heating system. One of them even showed me different clippings about the co-operative that she had collected from newspapers.

APPLYING NEW TECHNOLOGY: THE PATTERN OF USE

In every house there was a main thermostat that controlled the temperature of the waterbased floorheating system. This could be regulated according to the need of the users. The measuring unit was not degrees Celsius, but a scale from one to five, five being the hottest. However, none of the end-users could tell me how the scale translated to degrees Celsius. The end-users had to use a trial-and-error strategy to find the preferred indoor temperature. Some of them told me that they had spent up to 6 months before they found their comfort, and knew enough about the scale to be able to adjust the temperature if they needed to do that. The technically interested found this learning-by-doing process interesting. However, the non-technically interested preferred to ask others for help instead of trying themselves.

Most of the end-users told me that they adjusted the installation only twice a year; in the spring and in the fall. They operated with one summer temperature and one winter temperature, and they were satisfied with the comfort it provided. The fact that they hardly ever (only twice a year) had to interact with the system was one of the *positive aspects*; "It's so easy, practical and comfortable, compared to all other energy sources I have had earlier. I don't even have to think about it"

The waterbased floorheating is mechanical and it is not possible to programme it in such a way that it lowers the temperature in certain periods during the day or night when nobody is home or they are sleeping. Day- and night lowering can reduce the energy use without reducing the end-users comfort. Even though this is not possible in the houses, some of the houseowners try to limit their energy use. Truls told me that he and his family always closed the doors to the areas that did not have waterbased floorheating or that for other reasons they did not want to heat. Later, -they could open the doors to the rooms they wanted to heat and heat was distributed around the house. Truls and his family had their waterbased floorheating system set on about 17 degrees Celsius, but they preferred an indoor temperature of 21 degrees Celsius. In order to raise the temperature and to reach the required level of comfort, they used to burn wood in addition. Truls and his family tried to reduce their energy-use when they were not at home or asleep at night. He said he felt it was a waste to use more energy than they needed to, even though they lived in a low energy house. However, Truls was the only informant who talked about sustainability and global responsibility.

Trine, another owner in the co-operative, told me that she always had the heat on. She never tried to use less energy by shutting doors or do any of the other tings Truls did. She adjusted the installation twice a year (winter- and summertemperature) and that was it. The fact that she did not have to do anything was part of the reason why she was so pleased with the system. She liked the house to be comfortably warm at all hours, even when she went away for the weekend because she enjoyed coming home Sunday afternoon to a nice and warm home. Trine told me that she also had waterbased floorheating in the bedroom turned on 24 hours a day, even though she had the bedroom window open during the night. She said that she at first found it unusual and a bit strange not to economise with energy because, previously, she had always been a careful energy user, but she soon got accustomed to it. Trine explained that there was no point in economising with energy in these houses because indoor temperature was controlled by outdoor temperature. A temperature sensor was connected to the common heatpump and the heatpump responded to the outdoor temperature and elevated the temperature of the water distributed to all the houses. Therefore, Trine said, she did not see how she could reduce the amount of energy she uses.

To summarise, owners in the co-operative had an identical use of the energy technology concerning the adjustment they had to perform two times a year. They described the adjustment they had to do from time to time as fairly easy and if they could not get it right they either asked a neighbour or looked it up in the user manual. The technologically interested said they used quite some time to get to know the installation and how to use it. By a trial-and-error strategy they gradually got a good insight about how the technology worked. However, the end-users had uneven understanding of the technology and consequently they led quite different lives in the low energy houses.

LEARNING TO USE NEW TECHNOLOGY

To use new technology involves establishing new patterns. Heating systems like waterbased floorheating and heatpumps are still not very common in Norway. Therefore, it is reasonable to assume that the end-users had to learn something new when they move into their low energy houses. The heating system of a low energy house is suppose to provide users with the comfort they want and at the same time do this in such a way that the house do not use more energy than it needs to.

When the houseowners bought their new homes they did not know much about how the heating system worked. They had attended an information meeting held by the housing co-operative before they bought the house, and at that meeting they had briefly been introduced to the new system. One of the houseowners in the co-operative had been asked by the housing co-operative to act as responsible for the operation of the common parts of the system. If owners had any questions or needed help they could contact him, and he would either help them or contact someone who could.

All houseowners also received a user manual when they moved in. This manual described how to operate the system. This manual as well as the appointment of a person responsible for running the system was what the co-operative organised to train users. Some of the users told me that, in addition to this, a technician had given them a tour around the house and told them a bit about how the technology worked and should be used. Another end-user told me that she had tried to look over the technician's shoulder when he was installing the system, and in that way attempted to understand how the technology worked. But she laughed when she told me that it had not been very successful because she had not see much and she did not understand anything. Still she said that she felt she knew enough about how the energy technology worked because she hardly ever adjusted it. And the rare occasions when she had to adjust/regulate the energy technology she used the user manual. She almost always made it work the way she wanted, and if she did not she asked one of the neighbours. They knew more about how it worked and they were always willing to help her.

Some of the houseowners were engineers or had a technical interest. These end-users told me that the heating system was so easy to use that they could not see that any training was needed. They explained that when the system was running more or less on its own. These users said that they had fairly good knowledge about how the technology worked and how they could use it. They discussed different aspects of the system with each other and shared their experiences. The technically interested and the technically uninterested both agreed that there was not much to learn about the new heating system. They found it easy to use, and they tried to learn from each other.

All the houseowners in the co-operative had the same heating system. They might not have the same problems, but they felt part of a community where they could discuss and consult about pros as well as cons of the system. In addition to this they had the user manual as a safeguard, as well as the operating person. All in all, this meant that the system could be explored in a safe setting, which may be the reason why none of the users experienced any serious problems concerning learning how to use the system.

CONCLUSION

This study supports previous findings that users seldom change their pattern of energy use in order to save money (Kongsli 2001). In the co-operative they did not pay equivalent to the energy they actually used, but according to the size of the house. Never the less, some users chose to save energy. However, this case study has shown that the acquisition of a low energy

house, even among those interested in saving energy, were not primarily motivated by issues of sustainability. They had other motives, like location, which were far more important to their decision.

However, all the informants were positive to the heating system and said it was something that made their houses even more attractive. And after living in the houses a while they said they could not see them selves living in a house *without* that kind of heating system. The users were proud of and satisfied with the houses and the technology.

The heating system was not equally easily accessible for all users, and the case study showed that it was an advantage to have some technical skills. The technically skilled were able to use the house slightly more "correct", energywice, than those without such skills. However, the technically uninterested did not describe learning and using the heating system as difficult or complicated. They said it was quite easy to use and besides the heating system was running more or less on its own. And the users were quite happy to delegate much of the heating tasks to technology. This might be due to the secure setting within which learning and using took place, also characterised by "good" (constructive) communication between the houseowners and the builders (who sold the houses), as well as among the houseowners. The fact that the users so seldom reported problems also indicates that the low energy house and the heating system have been domesticated in a successful manner

A main conclusion from this case study is that a more widespread use of heating systems like heatpumps and waterbased floorheating may be more dependent on the supply of such houses that the demand. Most of the owners in the collective were not particularly eager to find a low energy house for the sake of its efficient heating system because this is a marginal quality of a house, compared to its location, its design, etc. However, when offered an efficient heating system as a part of an otherwise attractive deal, they found this quite attractive.

In terms of policy, this suggest that it will be difficult to find economic measures that would make people more interested in buying low energy houses. Thus, the challenge is to make constructors build such houses. Many people may learn to enjoy new efficient heating systems and, according to this case study, there will be no serious resistance. But we cannot expect people to make decisions about buying a home primarily on the qualities of the heating system.

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Green Procurement: strategy and practice

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1. INTRODUCTION

The Dutch Ministry of Transport, Public Works and Water Management wants to provide space for the market to develop good ideas that contribute to better and more sustainable solutions in civil and hydraulic engineering. This means more space for innovative building contracts and less for the traditional detailed specifications. However, giving more freedom to market parties also implies the risk of sustainable building being neglected by the contractor.
To see to it that a minimum level of sustainable building is guaranteed or - even more desirable – encouraged within innovative building contracts, the Ministry has had a study carried out into the possibilities of "green procurement". Simultaneously, practical experience with "green procurement" was gained with several projects.
In this paper, the main results of the "green procurement" study are discussed, as well as a number of practical experiences. Finally, it is shown how "green procurement" can be incorporated in the policy of the Ministry in nearby future.

2. GREEN PROCUREMENT STUDY

2.1 Green procurement – why

2.1.1 The European context. Green procurement is an issue that is not unique to the Netherlands, but relevant to all member countries of the European Union. The European context for "green procurement" is formed by the competition policy (DG Internal Market) , the environmental policy (DG Environment) and the innovation policy (DG Enterprise). It is notable that these policy fields are closely interwoven. Ideally, these policy fields should reinforce each other, but in practice there is also tension. The environmental policy aims at a sustainable European development. As governments are major clients and buyers, they can make an active contribution to sustainable development by means of "green buying". This, incidentally, is an interpretation of the actions as formulated within the scope of "competitiveness of the European Construction Industry". However, "green purchasing" will always have to be done within the frameworks of the European procurement directives and competition rules. The key question regarding green procurement is in how far there are possibilities to let sustainable building play a role in the procurement process. In 2001, the European Commission published an interpretative document on this subject.

2.1.2 The sustainable building policy of the Dutch government. The Dutch government has since the mid-nineties been pursuing an active policy in the field of sustainable building. In the long term, the aim is to establish sustainable building in building regulations. In advance of this, "building departments" such as the Ministry of Transport and the Governmental Buildings Agency play an exemplary role in the field of sustainable building. For the Ministry of Transport this means that it is standard to apply the so-called "Nationaal Pakket Duurzaam Bouwen" (National Package Sustainable Building) for the construction of infrastructure. This package contains 87 sustainable building measures. The application of this package has been anchored in the National Transport and Traffic Plan.

2.1.3 Procurement is a "weak link" in sustainable building. Mentioning sustainable building ambitions in policy documents is not sufficient for the actual sustainable construction of infrastructure. This means that sustainable building will have to be organized well in the procurement process and in practice this proves not to be simple. Recognizable practical problems are: not including sustainable building in the demand specification, not being able to define what is meant by "sustainable", etc. In a more fundamental way it is the question whether sustainable aspects can play a role in the selection of contractors and the awarding/allocation of building orders. An additional reason for the Ministry to pay attention to sustainable building at procurement is the new procurement policy of the Dutch government. Stimulated by the Ministry of Economic Affairs, "innovative procurement" was launched. Translated into the practice of the Ministry of Transport this means that contractors will be given more freedom to choose their own solutions and work methods.

2.2 What is green procurement?

2.2.1 The definition of green procurement. Green procurement can be described as: "Guaranteeing and encouraging sustainable building in the processes of drawing up contracts and procurement". This definition shows that there are two approaches to green procurement, namely "guaranteeing" and "encouraging". The "guaranteeing" approach aims to realize a minimal level of ambition for sustainable building. Ambitious clients will, however, aim at attaining a higher level. For this purpose, incentives will have to be built into the processes of drawing up a contract and procurement.

2.2.2 Possibilities for green procurement. With the study, the possibilities for green procurement have been mapped systematically. The scope for procurement was interpreted broadly and contains the following four steering moments (see figure 1): demand specification/requirements study, selection, allocation and testing. Following on these four steering moments it is also possible to consider bonus/penalty schemes as an incentive for the contractor to pay more attention to sustainable building. The following sections describe the possibilities of green procurement by means of these four steering moments.

2.2.3 Steering moment - demand specification (requirements study). With the demand specification, the client lays down the minimum level of ambition for sustainable building. In theory, this is the most powerful steering moment for green procurement. The effectiveness with which the client can use this steering moment is, however, determined by:

- The "hardness" of the requirements. Requirements can be distinguished according to "hardness", with a distinction between obligations to obtain results and obligations to strive for efforts. Sustainable building requirements should preferably be as hard as possible.

- The degree in which sustainability can be defined unequivocally and clearly. To prevent misconceptions and discussions, the client needs to be able to indicate clearly and objectively what he means by sustainability. Assessment tools are necessary for this.

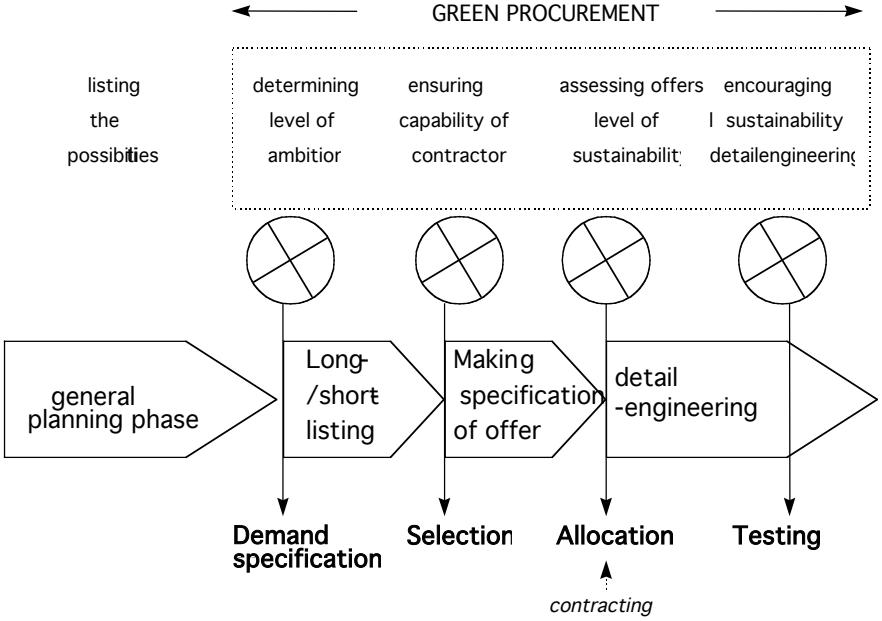

Figure 1) Steering moments and bonus/penalty schemes for green procurement

2.2.4 Steering moment - selection. This steering moment aims at ensuring the contractor is capable in the field of sustainable building. A distinction can be made into minimum requirements (grounds for exclusion and suitability requirements) and further assessment aspects. The European procurement directives include a limitative list of grounds for exclusion, an example of which, in relation to sustainable building, are environmental offences that have been committed. For the application of further assessment aspects, the contractor has a relatively great deal of freedom. In any case, the selection criteria and the way these are applied should be transparent, verifiable and as objective as possible. Suitability requirements and further assessment aspects regarding sustainable building are, for example, experience with ecological design, experience with large-scale application of secondary building materials etc. The application of selection criteria will have to take place skilfully. Setting strict requirements will lead to the number of potential contractors decreasing resulting in a higher price.

2.2.5 Steering moment – allocation/awarding. This steering moment is about judging the level of sustainability of the offer. In accordance with the European procurement directives, allocation can take place on the basis of the lowest price or the most profitable offer from an economic point of view. With allocation based on the lowest price, the client will only have to check whether the offer's sustainable building rating meets the requirements study. This way, a minimum level of sustainable building is guaranteed. However, contractors are not encouraged to pay extra attention to sustainable building. If allocation takes place on the basis of the "most economically advantageous offer", sustainable building can be used as a criterion for allocation to encourage the contractors to fit more elements of sustainable building into their offer. As this takes place in a price-competitive situation, it is an effective way of promoting sustainable building. However, to prevent arbitration and discussion, clients should be capable of comparing the sustainability level of different offers objectively. For this, assessment tools are essential. For the civil and hydraulic engineering sector, the Ministry of Transport is currently developing an assessment-tool for sustainable building ("Dubocalc").

2.2.6 Steering moment - testing. After a building commission has been given to a contractor, it will have to be checked during realization whether it is carried out according to the contract. A plan for testing will have to be drawn up in which attention to sustainable building is paid. According to the new policy of the Ministry of Transport, Public Works and Water Management, this takes place according to the principle of external quality assurance. The first responsibility for assurance lies with the contactor.

2.2.7 Bonus/penalty schemes. In addition to the four steering moments, bonus/penalty schemes can also be considered to encourage the contractor to pay more attention to sustainable building. If a choice is made for bonus/penalty schemes (within a design construct contract) these can be applied at three moments, being: the offer, the working out of a design and realization/execution.

3. PRACTICAL EXPERIENCE WITH GREEN PROCUREMENT

3.1 Highway 11 between Alphen aan de Rijn Bodegraven (the Netherlands)

The Highway 11 is a new, seven-kilometre-long highway that is to be constructed between Alphen aan de Rijn and Bodegraven. This is a design-construct-maintenance contract of approximately 59 million Euros. The demand specification (see section 2.2.3) includes the general preconditions regarding the sustainability and integration into the environment. Furthermore, a point system for the selection of contractors (see section 2.2.4) and allocation was drawn up during the preparation phase (see section 2.2.5). The selection system for contractors contained elements as: having an ISO 14.000 certificate, experience with the application of secondary building materials and experience with ecological design. The assessment system for allocation contained elements as: maximum reuse of raw materials, limiting the use of space, building with a minimum of materials and energy-saving design. As it turned out, the point system for selection and allocation was not used for fear of legal complications. One may conclude from this that the legal context is a very dominant factor in green procurement. Point systems to be used should be transparent, objective and verifiable. Furthermore, requirements set should be relevant to the nature and size of the project and must not work discriminatorily in the market.

3.2 Dutch Highspeed Line

The Dutch Highspeed Line is a railway connection of approximately 100 kilometres from Amsterdam to Brussels and is part of the Trans-European Network of Highspeed Raillinks. This is a series of design-construct contracts with an average value of approximately 400 million Euros each. The demand specification (see section 2.2.3) includes the general preconditions with regard to sustainability and integration into the environment, e.g. the application of secondary materials, provable energy-saving and material-saving design, and limiting waste and emissions during the whole lifespan. In addition, for the selection (see section 2.2.4) and allocation, sustainable building was taken into account by means of a bonus/penalty scheme (see section 2.2.7). A selection criterion relevant to sustainable building was having “representative experience with designing according to a life-cycle approach”, the aim of which is optimising the total cost of ownership. From a sustainable-building point of view, this is favourable as many sustainable building measures entail additional costs, but save during the whole lifespan. For allocation, a bonus/penalty scheme was applied which basically boils down to a price correction. When an offer scored better for sustainable building, the price of the offer was adjusted downwards, which increased the

chance of allocation. Sustainable building and environment were assessed for construction nuisance, design & integration into the landscape, and sustainable design.

4	4: - or + total of bonus/penalty for 'other assessment criteria' (e.g. sustainable building)
3	3: + present value of maintenance 11-25 years
2	2: + present value of maintenance 0 – 10 years
1	1: present value of the offered price

Figure 3) Composition of the offered price at Dutch Highspeedline

The assessment result "Sustainable Building" had a maximum bonus and penalty of approximately 5% of the present value of the offered price. On the basis of the intended sustainable building allocation criterion, all tendering firms paid considerable attention to sustainable building in their basic offer, from which one may conclude that market parties can effectively be encouraged to pay more attention to sustainable building by means of bonus/penalty schemes at allocation.

3.3 The Borkeld Ecoduct (the Netherlands)

The Borkeld Ecoduct is a wildlife-passage for deer to reconnect two parts of the Dutch Ecological Main Structure, which are transected by the A1 highway. This is a design-construct contract, the value of which is approximately 4 million Euros. The demand specification (see section 2.2.3) states that as many fixed measures as possible from the National Package Sustainable Building (see section 2.1.2) should be applied. Sustainable building was considered as one of the criteria for allocation (see section 2.2.5). The assignment was allocated on the basis of the most economically advantageous offer being the offer with the highest price-quality index. The index was composed as follows:

PKi = 0,60K + 0,40P
PKi = price-quality index
K = quality score (including sustainable building weighing facto 15)
P = price score

Figure 4) The Borkeld wildlife passage: allocation system for offers

The tendering firms had to submit a price and a preliminary design. Two of the three firms followed the instructions of the requirements study and applied the National Package Sustainable Building for Civil and Hydraulic Engineering. As they had a great deal of freedom, this led to very divergent designs incorporating sustainable building in different ways. One of the tendering firms had for example accentuated limiting construction nuisance. The third tendering firm had not followed the requirements study's instructions for sustainable building and was given a bad sustainable building evaluation. One may conclude that sustainable building can be guaranteed effectively by including sustainable building demands peremptorily in the requirements study. Moreover, it can be concluded that including sustainable building as a criterion for allocation had a positive effect on the ultimate level of sustainable building in the offer.

4. THE MINISTRY'S POLICY

The examples in chapter 3 show that "green procurement" can in practice lead to more sustainable solutions. However, one must realize that these are pilot projects. In practice, clients find green procurement awkward, for which basically two causes can be given namely: lack of knowledge about the possibilities of green procurement and lack of instruments to shape green procurement in practice

4.2 Solving the bottlenecks of green procurement

To solve the bottlenecks of green procurement, the Ministry of Transport, has drawn up a step-by-step plan for green procurement. Central to which are on the one hand the development and distribution of knowledge and on the other the development of a set of tools to facilitate green procurement. This toolbox will be filled with instruments clients can use for green procurement such as: guidelines for green procurement, aids for green procurement (assessment tools, sustainable building specifications, etc..

4.3 Anchoring green procurement in the policy

Green procurement is about realizing sustainable building ambitions within the frameworks and preconditions of procurement directives and sustainable building policy on a national and European level. This means that effective sustainable building will have to be guaranteed within both the environmental policy and the procurement policy of the Ministry.
The sustainable building ambitions for the Ministry of Transport, have been laid down in accordance with policy in the National Transport and Traffic Plan (see also section 2.1.2). This basically boils down to the Ministry, from its exemplary role, constructing all its infrastructure according to the principles of sustainable building. The Ministry of Transport, contracts out the construction of infrastructure to the market. To realize the sustainable building ambitions, solid contracts will have to be made with market parties at procurement. To guarantee this, green procurement ideally will be incorporated in the so called "professional client" programme of the Ministry. This means that sustainability has a recognizable place within the organization of the buying and procurement policy.

5. CONCLUSION

With green procurement, an effective contribution can be made to more sustainable solutions in the building sector. This is why sustainable building not only deserves a place in the environmental policy of an organization, but also in the buying and procurement policy.

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Architectural and Technical Possibilities with New Building Components

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1. INTRODUCTION

A central part of the Ph.D. study deals with a generally useful method, that is in process of being developed. The aim is to refine the method so as to assure and control the quality of the design and choice of materials for building components, component system and whole buildings.
The method is to be used by building owners, users, architects, engineers and manufactures in decision-making processes early in the programming stage and later during design.

One of the objectives of Ph.D. study is to create a better understanding of ecological cycles and decisions based on quality and comprehensive assessments in the building sector for heightening the quality of architecture and protect humans and nature against exploitation of resources.

One of the objectives of the Ph.D. study was to prepare a State-of-the-Art, "Architectural and Technical Possibilities with new Building Components" (Andersen, 2002), that deals with a quality assessment of a series of new and well known building components and systems as well as buildings. The assessed components are primarily based on components and systems in renewable materials, but it is also important how these law technology components, mainly plant based components, can be combined and integrated with more traditional high technology components and systems.

2. BACKGROUND

2.1 Global and national strategies

The global aim is to reduce the CO_2 emissions for to counteract the greenhouse effect.
In Denmark shorter building processes and higher quality than today and lower price are demanded.
It is the intention that architects together with the building industry are to develop and design industrialised building components with the purpose of simplifying the building process and make it more efficient (The Ministry of Housing, 2000).

2.2 Quality, sustainability and overall solutions

It is important that the co-operation not focus exclusively on lower price, at the expense of quality and sustainability. Overall solutions should broadly consider the building actors, so that comfort, health and user consideration are prioritised together with good healthy materials, valid technical solutions and a good indoor climate.

2.3 Life cycle analyses and documentation

Earlier investigations (Andersen & Johnson, 1999) show, that by using Life cycle analyses (LCA) it is possible to reduce the environmental load of buildings by about 55 % replacing the 5 building elements and materials, with the most impact without changing the aesthetic and function.

By changing the aesthetic, if is possible to make the building even much more sustainable, but by so doing it may become another building with another signal valency.

2.4 The "real" product and sustainability

On the market today are many different building components of different manufacture, and not all are labelled equally well. Composite building components cannot be separated and disposed of and the glue is not all ways environmental sound.

Many users demand certified products, the "real" product and good quality. It would be desirable if the manufacturers labelled their product better, so that information about contents, emission of harmful substances, disposal and life cycle could be compared.

3. METHODS

3.1 Quality assessment

My assessment of new and well known building components that enjoy renaissance resulted in a State-of-the-Art (Andersen, 2001). The tested method is how to assess some different primarily plant based building components. The quality assessment takes its point of departure in the following concept:

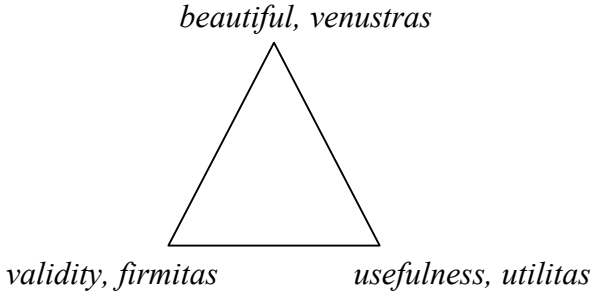

Figure 1 Vitruvius` Trinity year 0

3.2 Vitruvius` Trinity year 0

The quality can be defined on the basis of the Roman architect and engineer Vitruvius` concept of a trinity concerning validity, usefulness and beautyful (firmitas, utilitas, venustras). This concept also applies today in an updated form.

3.3 The updated form of Trinity

The concept is adequate for quality, comprehensive assessment and balance in year 0. The concept was used as object in the method.

A new factor is that global climate changes, CO_2 emissions and emission of harmful substances contribute to the parameters for environmental soundness being included in the original concept form year 0.

Today production methods and rentability are essential for visualising barriers or spreading possibilities. Therefore these parameters have also been added to the methods.

3.2 Themes
The following themes are used in the assessment:

- Architectural possibilities, usefulness and beauty
- Technical properties, indoor climate and validity
- Production, resources and economy

4. DISCUSSION
4.1 Building components and integrated design
There are many ways to design and link building components, but it is essential that building components are usefull durable, valid, beautiful, simple, can be varied and additive in system connections, replaceable etc. to obtaine flexibility and individuality in the design process. In addition it is an advantage that environmental leads over the lifetime is small and contribute to a good indoor-climate. New building components contributes with news architectural expression, if they are original and can be designed and integrated in the whole building as units.

4.2 Building components and system connections
Detailed knowledge of the properties of materials the are good preconditions for making the best use of properties from several different materials. By combining materials, building components with maximum performance can be obtained and minimal consumption of materials.
The way that building components are connected and with what, is essential for the properties and the aesthetic of the finished product. The joining of the components can be with gluing, nailing, bolting and jointing etc. This for example not the compressive of strength of the brick alone that is interesting, but rather the system (the brickwork including joints) the properties of which it is interesting to know. In addition the properties of the components in relation to the building properties are essential, where for example the front leaf and back leaf will be connected by headers for stabilizing the wall in the finished building.

5. CONCLUSIONS
The treated components are more or less based on CO_2-neutral raw materials in wood, straw, grasses and plant fibre are found all over the world in plentifully quantities as cheap rest product.
The assessment of treated building components has shown what connections and parallels exist with regard to properties, design qualities a system solutions. The assessment also showed how the design and system solutions can be integrated in whole buildings and other components, and how it is necessary to combine the components with more high tech material and components or surface treated to obtain a certain performance.

5.1 Global renewable resources and valid = rentability
In order to reduce the CO_2 emissions designing and producing more building components based on renewable raw materials that can be procured and disposed of present a great potential. Building components of this type with long lifetimes in addition be profitable in comparison with many traditional building components in the industrialised countries an will meet the population growth and help the housing situation in the developing world.

5.2 Architectural possibilities = design qualities and material properties

The quality assessment shows that there are many good example and opportunities for connection with building components of renewable resources with more traditional high technology components or add plant fibres in materials like concrete, clay or plastic. This will give a better performance and new potential forms and new surface characters can be obtained.

When properties, material combinations and form can be choiced, it is possible to vary the performance and design impression depending on use and function. There is a possibility for designing a type of component that can be varied in proportion to a given neighbour and designs of whole systems that can join in neighbourhood with other systems.

Moreover, there are possibilities for designing products with a surface character depending on their use and individual aesthetic wishes. With time ages gracefully depending on use wood sort and the surface treatment. Plant fibres come in many different designs, sizes and colours can also be died.

5.3 Inherent properties and correct use = beautiful design

Wood for example has very differentiated inherent properties that contribute to its many applications and beautiful architecture. Wood can be carved in different dimensions and used to primary building parts, as building elements or bricks. The design qualities of wood can be used to aptering and furniture. By heating it is possible to bend and fold. Moreover it can be defibrated and used as reinforced fibres or as fill in fibre concrete and bricks of clay.

5.4 Technical properties, indoor climate and validity

Most of the investigated building components have good, documented technical properties like for example strength, lightness and insulating properties, but they are not to outside climatic impact such as moisture and ultraviolet rays. By correct use, treatment and maintance can the validity of for example facade claddings be extended.

Some types of material like wood or clay, have natural good moisture and indoor climate regulating properties.

Plant fibre components and straw composites are good alternatives to plastic components. Assuming that they are moisture resistant there are many possibilities for designing new light building components with great strength that can be disposed of. USA and Germany in the front in the car industry with components of this type.

6. PERSPECTIVES

The assessment has show that if the choice of material is included into the early in the design process it making design integrated qualities, but choicing materials to late it becomes pure technical. When the aim is to design optimal building components, it is early in the decision-making process some that qualitative choice need to be made.

Therefore a more refine method than the one used in the State-of-the-Art. The method ought to be more specific and progressive in relation to obtain optimal components, to assure and control the quality of the design in the design and solution processes. A method indicating specific “open” choices, for certain levels in the design and decision process with as well sensed as perceived the measure parameters. At a later stage the fewer possibilities exist for marking the finished product.

6.1 Usefullnes, validity and beauty = Vitruvius updated

The refined method should assist in the choice of material, building components and properties so that the best for a specific use, validity and beautiful is obtained to heighten the quality and sustainability of the buildings.

6.2 Guideline in the beginning of decision phases

Based of the quality assessment (State-of-the-Art) it is the meaning to establish a general refined method for:

1. Building owners, users, architects and engineers when selecting building components for a whole house at the beginning of the design phases in a building project, where the most decisions are made and later in connection with project design.

2. To initiate and/or adjustment of new building components and systems by manufactures.

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Sustainable low impact demonstration projects

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1 INTRODUCTION

Demonstration projects provide opportunities to study and implement new concepts, techniques and solutions to the challenge of sustainable architecture. When faced with the question of economic and technical feasibility of innovative responses, the development of demonstration projects allows the design team to study and test alternatives, to implement and evaluate solutions, to monitor and analyse results, and to transmit and promote better practice.

In a developing country with technological, economic and administrative limitations, demonstration projects can respond to the following challenges:

- adapt, implement and test the technological solutions developed in other situations.
- develop and test alternative solutions to those found in other countries.
- identify and resolve specific or critical problems arising from local contexts.

These projects also allow the testing and evaluation of new and improved standards, energy codes, specifications and legal requirements before general implementation.

The two projects presented in this paper provide examples of this situation, in the specific context of Argentina. The first project, the Fuentes-Lopez House located in Bariloche, the cold Andes lake district, was designed in 1999, constructed in 2000 and occupied in early 2001. This highly insulated solar house shows that it is possible to build innovative low energy buildings at the same cost as conventional houses in this region. The second project, the Interpretation Centre of the Ecological Reserve in the City of Buenos Aires, has reached the bidding stage, though the present economic crisis will delay construction. The design and documentation, together with detailed analysis and simulation, has provided valuable lessons for future projects

In the conclusions of this paper, preliminary results of these projects will be evaluated. Special reference will also be made to the impact of the current economic crisis in Argentina on the development of sustainable buildings.

2. SOLAR HOUSE IN BARILOCHE

The Fuentes-Lopez House in Bariloche, constructed in 2000 and occupied for over a year, is a single family house in the cold Andes region with very low energy demand and integration of various renewable energy systems. The house is sited in a large plot on a wooded hill-side, 18 km from the city centre. In winter, snow is frequent with a minimum design temperature is -6°C in winter, and an absolute minimum of -21°C. In summer the maximum average temperatures reach 24°C, with strong solar radiation due to the lack of pollution, the height of 950 m above sea level and the latitude of 41°S. 40% of the time there is good solar exposure, and cloudy and rainy days are distributed throughout the year (SMN, 1992). The house in the coldest region of the country (IRAM 1996a), has similar conditions to those found in the far south of the country, 55°S at sea level, and considerably colder than similar latitudes in Europe.

The client required a house with passive solar systems, including a glazed sun space, integrated photovoltaic panels, solar panels for hot water and excellent thermal insulation. This was achieved at the same cost as conventional construction (Sue Roaf et al 2001).

The house has provided high levels of comfort during the first winter, with a shorter season of auxiliary heating, compared with conventional construction. Figures 1, 2 and 3 show the section and floor plans of the house, while figures 4, 5, 6 and 7 show the construction and completed house. The design responds to the following factors:

Passive solar systems: The glazed sun space provides an intermediate space, protected from winds and rain, while providing heat for the interior on sunny days, when ventilation is required to maintain comfort. The nominal area of this system is 48 m^2 with forced convection transfers heat from the upper levels to a rock-bed under the house. This is complemented by direct gain through well orientated windows with a surface area of 7,50 m^2, and by thermal mass Trombe walls of 16 m^2**.**

PV panels: The grid connected system has 10 m^2 of amorphous panels, integrated into the roof with an inclination of 40°. As local costs are unfavourable, the system is dimensioned to minimise export to the grid and promote maximum local consumption. Initial monitoring indicates reasonable performance.

Solar hot water: The active system has 6 m^2 of collectors integrated in the roof with a slope of 40°, connected to a tank of 250 m3 located on the upper floor.

Thermal mass: To store solar heat and reduce temperature swings in summer, the rock-bed under the ground floor contains 10 m3 of selected rocks, while internal walls are of 16 cm solid brick in a reinforced concrete frame that also provides stability in this earthquake region.

Thermal insulation: The layers of insulation, 20 cm in the roof and 15 cm in walls, are fixed to the internal mass walls with a wooden structure to minimise cold bridges and avoid condensation. The result is a construction that exceeds the optimum level (IRAM, 1996b) by 25%. The costs of this construction were not higher than conventional construction, due to the reduction of expensive internal finishes and exposed timber.

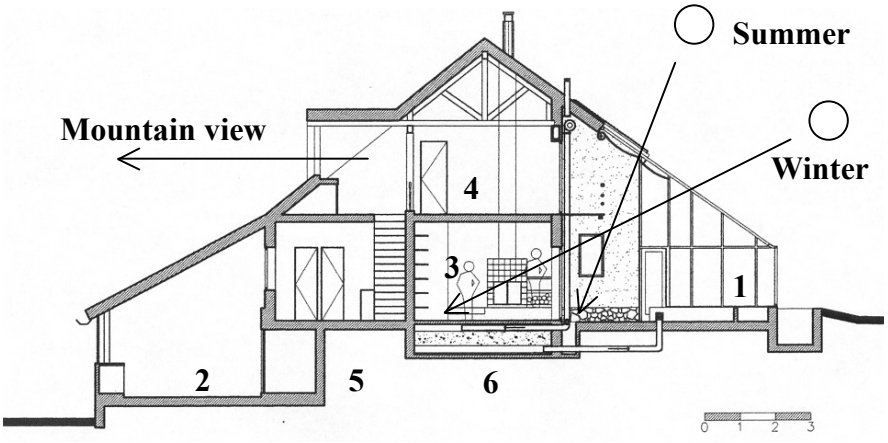
Materials: Locally produced materials such as stone, brick and timber were used where possible, though for economic reasons insulation was sent from Buenos Aires.

Labour: Local and relatively unskilled labour was used, producing satisfactory results despite the non-conventional construction. Special care was taken to seal openings and reduce air infiltration.

Site selection: A special sun-predictor was used to select the site of the house with good solar access and minimum tree felling. Models of the house and site topography were tested in the heliodon to verify solar incidence in different season of the year.

Figure 1.
North – South section

1. Sunspace
2. Car port & entrance
3. Living room
4. Bedroom, playroom
5. Wood store & cellar.
6. Duct to rock bed.



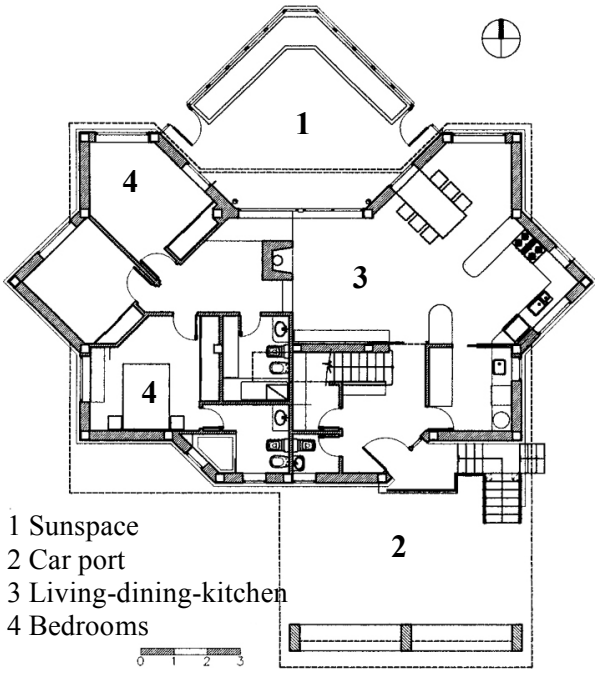


Figure 2. Gound floor

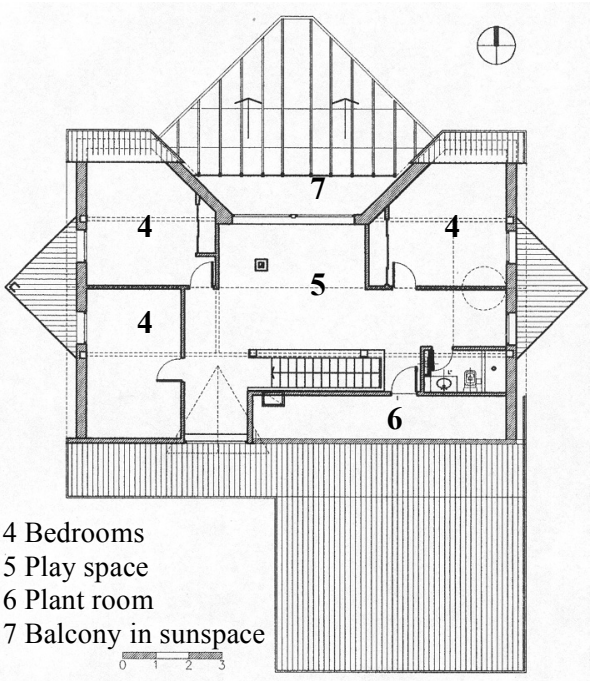


Figure 3. Upper floor



Figure 4
N facade under construction



Figure 5.
Dining & kitchen space



Figure 6.
PV panels integrated in roof design.
Insulation thickness:
15cm + 5 cm.



Figure 7.
Construction: Trombe wall with central window.

3. INTERPRETATION CENTRE

The Interpretation Centre of the Ecological Reserve Costanera Sur, on the urban waterfront, was commissioned by the Government of the City of Buenos Aires as an educational centre for school children visiting the Reserve, created in an area of land fill and lagoons formed on the waterfront close to the city centre. The central location, with an educational function at the entrance to the Nature Reserve requires a very low impact building with high demonstration potential. The project was designed to have very low energy demand, passive solar heating, natural cooling, good quality and distribution of natural lighting, solar hot water systems and PV panels in a grid connected system.

The location on shores of the River Plate has a sub-tropical temperate climate (IRAM, 1996a), with warm humid summers with average monthly maximum temperatures reaching 29°C, and occasionally exceeding 35°C, while summer night minimum temperatures are about 20°C on

average (SMN, 1992). Winter temperatures vary between 8.5 and 15°C, with absolute minimum reaching 0°C. Winds are not excessive, though the location on the wide River Plate estuary leads to an average wind velocity of 16 km/hr (SMN, 1992). Rainfall is distributed throughout the year, providing good conditions for vegetation growth.

The design of the project responds to the following factors:

Bioclimatic design resources: The bioclimatic design resources for *summer* include solar shading, reflective roofing materials on the outer skin of the well insulated roof, thermal mass in internal walls and floors, good through ventilation by stack effect and openings on opposite facades. The bioclimatic features for *winter* include solar gains, high levels of thermal insulation in walls and roof, as well as double glazing in windows. Thermal mass is used to store solar heat and control internal temperature swings.

Renewable energy systems: For hot water, *solar panels* with insulated storage tanks are incorporated close to the toilets and showers. *PV Panels* integrated into the roof satisfy part of the electrical energy demand, though this element does not attempt to achieve autonomy. As this system is grid connected, no batteries are required.

Water conservation: Although on the waterfront, mains water supply is limited, though capacity is expected to improve due to developments in the Madero Port area. Recycling of rainwater and grey water is implemented for flushing toilets and irrigation of planting around the building.

Low impact materials: Little data is available on the environmental impact and embodied energy of locally produced materials, so choices were made on the basis of direct knowledge of local manufacturing processes as well as general data from other countries.

Local technology: National production of building materials and the capacity of local building labour were also considered to reduce dependency, encourage local employment and avoid transportation impacts

Accessibility: The project is designed on one level without steps to provide easy access for all, without architectural barriers to limit circulation of those with mobility difficulties. Direct ramps are provided in the external circulation for the same reason.

Natural daylight: Following numerical simulation of daylight, special studies of natural daylight were made in the artificial sky to evaluate and improve light levels and distribution, especially in the Interpretation Centre. Complementary studies of lighting with direct sunlight and solar shading were also carried out in the heliodon solar simulator.

Thermal characteristics: The insulation levels are designed to exceed the A level (optimum) according to the national standards (IRAM, 1996b); unusually high for Buenos Aires. Simulations of temperature distributions within the construction were required to avoid cold-bridging and condensation, while dynamic thermal simulation showed the advantages of these thermal properties in both summer and winter.

Non conventional systems: To avoid air conditioning, a cooling system was designed using subterranean water, circulated through pipes in the floor slab. The same pipes are used for heating by an auxiliary gas boiler in winter, when solar gains are insufficient.

The design of the building is based on a favourable north-south orientation of the main facades, while maintaining a fairly compact plan for economy, thermal inertia and controlled heat losses in winter. The guidelines for sustainability, established at the start of the project, helped to define the initial form that was refined during the design process. Figures 8-12 show the design of the building, with plan, section and a photograph of the model.



Figure 8
Location plan and outdoor spaces:

1 Access patio
2 Pedestrian access
3 Pedestrian path
4 Patio for snacks
5 Outdoor activity

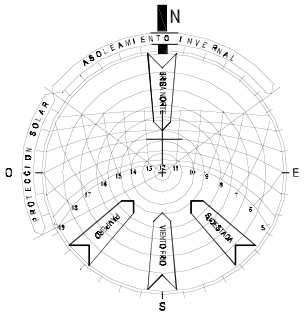


Figure 9.
Sun path & prevailing winds
Buenos Aires, latitude 34°S

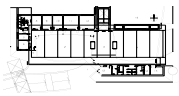


Figure 10: Ground floor
1. Main entrance,
2. Interpretation centre,
3. Access hall,
4. Activity hall
5. Acceso personal,
6. Security office,
7. Reception,
8. Administration,
9. Offices for guides
10. Meeting rooms,
11. Reception,
12. Plant room,
13. Store
14. Patio



Figure 11
View from NW:
- Protected west facade
- Roof overhangs for summer shade
- Good winter solar access
- Roof integrated PV panels
- Solar panels for hot water
- Trombe wall panel

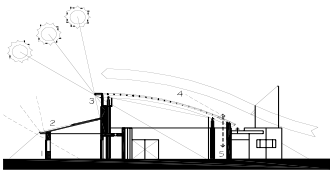


Figure 12.
Section, Interpretation Hall:
- High level windows
- Curved roof for solar gain and wind protection
- Overhangs for shade
- Mass walls and floor for thermal inertia
- Light ducts

4. CONCLUSIONS

Both projects, undertaken by the Research Centre Habitat and Energy, of the Faculty of Architecture, Design and Urbanism, University of Buenos Aires, with design and working drawings prepared in the framework of the Technical Assistance Programme for Bioclimatic Architecture, has incorporated research results and provide feed-back for teaching. They demonstrate the feasibility of sustainable buildings with low environmental impact and high energy efficiency, implementing bioclimatic strategies and integrating solar systems in architecture, planned with a programme of monitoring and audits of the energy and thermal characteristics. They also highlight the need for further detailed information for designers searching for sustainable solutions in architecture.

The construction of the first project has been completed and occupied, with very favourable results during the first year. Limited monitoring is in process due to the distance of over 1800 km from Buenos Aires. The contract for the second project has been delayed due to the present economic situation, which has also affected the feasibility of some design solutions. For instance, imported PV modules have now tripled in price, but locally manufactured flat plate solar panels now cost less than imported panels and are more competitive due to the rise in gas prices.

In Argentina, as in many developing countries, there is a lack of detailed information on life-cycle analysis of materials, durability of construction and other aspects of sustainability in the built environment. However, this must not be used as an excuse for inaction or ignoring the search to produce more environmentally friendly buildings.

The current economic crisis underlines the need for sustainable building, as conventional non-renewable energy costs are rising sharply and imported materials have tripled in price. Low energy, low impact and long life buildings are not a luxury but a necessity in the current context.

ACKNOWLEDGEMENTS

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Water Reclamation and Sustainable Landscape Practices in and around a Green Building

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1. INTRODUCTION

Battery Park City (BPC) is a 92-acre public/private development in Lower Manhattan, New York City, created by the Hugh L. Carey Battery Park City Authority (BPCA) under the auspices of the State of New York.

In 2000, the BPCA released stringent sustainability guidelines for residential buildings known as the Hugh L. Carey Battery Park City Authority Residential Environmental Guidelines. In early 2002, similar guidelines will be released for commercial development. One residential building and two park projects now under construction are the first projects to implement these guidelines. All remaining design and construction projects planned for Battery Park City – six residential buildings and two commercial buildings – will be required to follow these guidelines as well. This will result in a mixed-use development with structures and open space that are designed, built and maintained in an environmental, sustainable manner. BPCA, a public benefit corporation, hopes these guidelines and projects will serve as pilots for similar projects throughout New York City and beyond.

The guidelines are divided into five general categories: Energy Efficiency, Enhanced Indoor Environmental Quality, Conserving Materials and Resources, Operations and Maintenance, and Water Conservation & Site Management. This paper addresses some of the guidelines that make up the fifth category, Water Conservation & Site Management. These guidelines include requirements for water conservation and reclamation, innovative water technology, and responsible landscape practices.

In this paper, I will address some of the technologies BPCA's present projects are implementing to collect, reclaim and reuse water as part of sustainable building and landscape practices.

The new water reclamation guidelines are timely for New York City. According to the City of New York Department of Energy Protection, the reservoirs feeding New York City are currently at only 59.5% of total capacity. Normally at this time of year, they would be about 96% full. The current capacity downturn is due to unusually light snow and rain: Average precipitation in February and March of 2002 totaled only 5.21 inches, down nearly 20% from the historical average of 6.36 inches. As a result, New York City is now in what is known locally as a Stage 1 Drought Emergency, meaning that the watering of lawns and other plantings is limited, washing of sidewalks and streets is prohibited, and ornamental fountains must be either recirculating or not run at all. The drought restrictions place further limitations on non-recirculating, watercooled air conditioning and refrigeration and water-cooled air conditioning with cooling towers. In addition, restaurants may serve drinking water to customers only upon request.

New York City treats approximately 1.4 billion gallons of waste water per day. It is expected that BPCA's new green residential building will save 35,000 gallons of potable water a day in peak season and cut by that amount the waste water going to a New York City facility for treatment.

Battery Park City Authority's first green building, and very likely the first green high-rise residential building in the United States, is now under construction. Referred to as "20 River Terrace," it is being built by the developer Albanese Development Corporation. The Design Architect is Cesar Pelli and Associates Inc., and the Architect of Record is Schuman, Lichtenstein, Claman, Efron. The high-rise building, when completed, will be approximately 335,000 square feet in area and provide 282 dwellings over 27 floors.

Adjacent to 20 River Terrace, BPCA is building a new two-acre public park that will benefit from the high-rise building's water reclamation. Known as Teardrop Park, it has been designed under the auspices of the landscape architectural firm of Michael Van Valkenburgh, Associates Inc. As is the case with all parkland in Battery Park City, maintenance of Teardrop Park will be carried out by the Battery Park City Parks Conservancy (BPCPC), a not-for-profit arm of BPCA dedicated to the care and programming of the 30 acres of parks within Battery Park City. BPCPC has created sustainable landscape practices for all the parkland within Battery Park City. Teardrop Park actually exceeds these practices to meet the spirit of the residential guidelines.

Another adjacent new public park, Site 23/24 Playing Fields, will similarly follow the sustainable practices of BPCPC and include additional sustainability measures as well. The Playing Fields have been designed under the auspices of the HOK Planning Group. Specifics of the sustainability measures of both parks shall be discussed within the sustainable landscape practices section of this paper.

The design and construction of 20 River Terrace follow BPCA's Residential Guidelines. The intents and requirements, as well as the developer's proposed technologies for water reclamation and sustainable landscape practices, are discussed below.

2. WATER RECLAMATION

2.1 Storm Water Management

2.1.1 Intent: Minimize the impact of storm water on New York City's storm water system, and minimize the use of potable water for maintenance and landscaping purposes by treating and recycling water.

2.1.2 Requirements: Provide for 100% of all roof and setback rainwater to be collected and then reused for maintenance and landscape irrigation by providing on-site storage, treatment and infrastructure.

2.1.3 Proposed Technologies: All roof rainwater shall be collected in a 15,000-gallon storage tank located within the building footprint. It will be reused, with no filtering necessary, for the maintenance and irrigation of the proposed roof gardens of the building.

2.2 Innovative Water Technologies

2.2.1 Intent: Minimize the impact on New York City storm water system and sewer system, and minimize the use of potable water by treating and recycling Grey water from lavatories, showers, sinks, laundry, and dishwashing facilities. (Grey water is waste water that does not contain sewage or fecal contamination; it can be reused for non-potable uses after simple filtration.)

2.2.2 Requirements:

1. Use Grey water for flush toilets, for cooling tower make - up (if applicable and properly treated), and for irrigation (if applicable and properly treated).
2. Provide separate supply infrastructure and (if applicable) waste infrastructure for Grey water system - separate piping, pumps, and valves.
3. Grey water systems and components to be located on site. Use ecology-based natural filtering technology, as opposed to chemical treatment. Provide adequate space within the building for storage, treatment, and necessary infrastructure.

2.2.3 Proposed Technologies: The developer has determined that it is more economical to use a Black water reclamation system because it eliminates the need for separate waste piping and results in only minimal additional operational costs. (Black water is defined as waste water that is collected from all building sources, including from toilets and in-sink garbage disposal units. As a result, Black water is higher in organic solids content than is Grey water.) This is the first residential building in New York City to receive approval from the Department of Health, Department of Buildings and Department of Environmental Protection to use a Grey or Black water system.

The proposed water-reuse system treats Black water via a biological system using microorganisms to break down waste. The system comprises an oxidizing agent, coagulant, and polymers used in conjunction with clarification and gravity filtration.

The system has been created by Applied Water Management Co. and will include an aerated influent feed tank, trash trap to intercept non-biodegradable solids, three stage biological treatment (anoxic mix tank, aerobic digestion tank with recirculation to the anoxic tank, and filter tank containing ultrafiltration membrane assemblies to remove suspended solids), ultraviolet light disinfection, ozone oxidation for color removal, and the finished water storage tank. See Table 1.

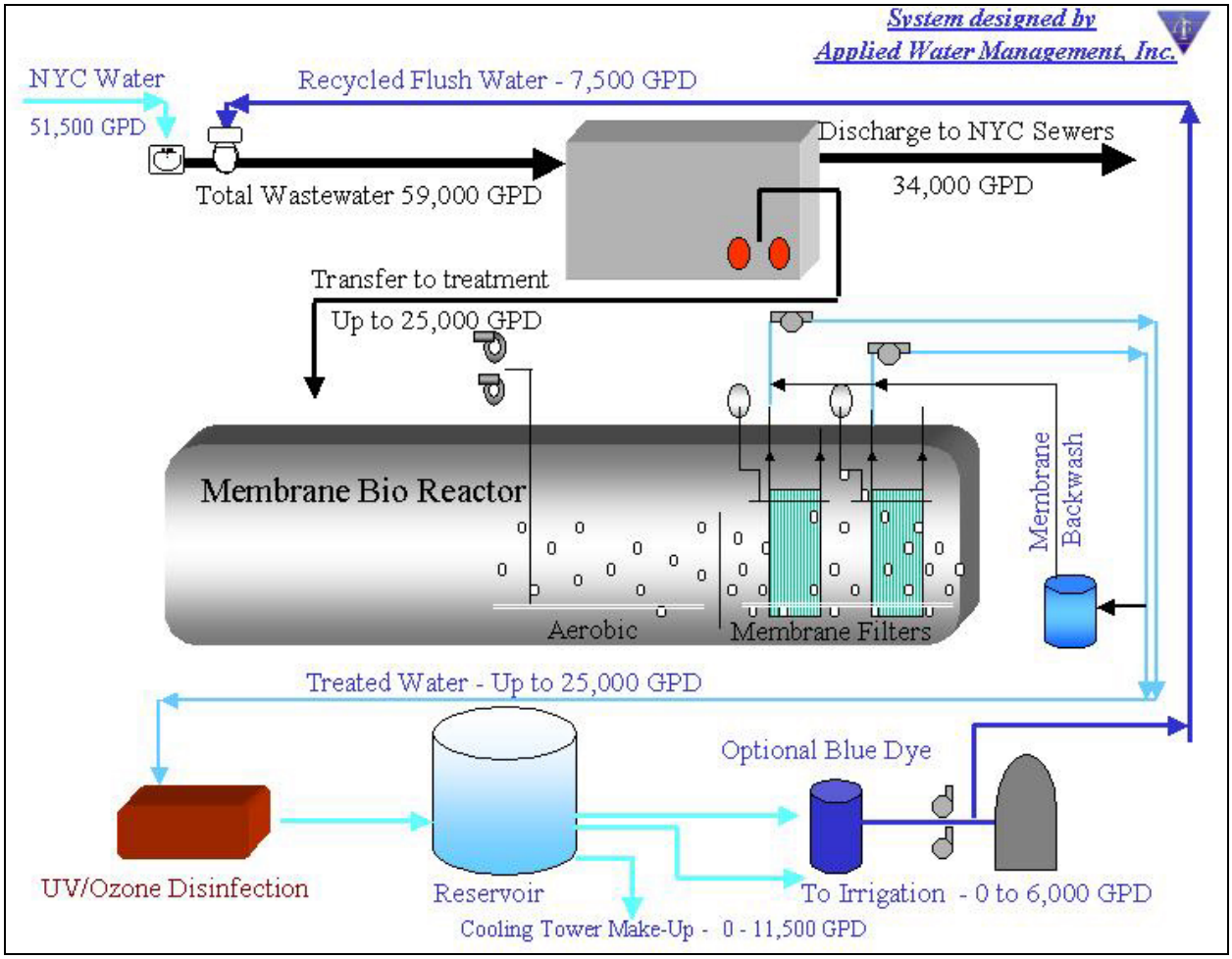

Table 1 – 20 River Terrace Water Reclamation System

Primarily, this water will be used for toilets and the makeup water for the cooling tower. Treated effluent to be recycled will have the following typical properties:

Biochemical Oxygen Demand (BOD)	< 10mg/l
Total Suspended Solids (TSS)	< 10 mg/l
Fecal Coliform	< 20/100 ml

Originally, the water collected was slated to be used only within 20 River Terrace and the adjacent Teardrop Park. Subsequently, the developer of 20 River Terrace was selected to develop an adjacent residential building as well. The latter is of a similar scale and located approximately 150 feet from 20 River Terrace. The opportunity to use one treatment plant for both buildings was found to be not only feasible, but economical and efficient. By upsizing the tanks from 20,000 gallons to 25,000 gallons, enough water can be treated in one building to fulfill the needs of both buildings. As a result, the decision was made to have the one water treatment system service both residential buildings.

A secondary use for the Black water, approximately 5,000 gallons per day, will be the drip irrigation of Teardrop Park. While the Department of Health prohibits the use of reclaimed water for fountains, maintenance or irrigation using pop-up heads, the department does allow its use for any irrigation that does not come in direct contact with residents and visitors. Because of the expected salt levels, a reverse-osmosis desalinization treatment system will be utilized to prepare the water for irrigation use. Because there is no existing data on similar

use of Black water from a residential building for irrigation, and because the system is recycling, which intensifies the salt levels to a level not now knowable, it cannot be determined at this time the extent of additional filtering required. Once 20 River Terrace is fully operational, full testing can be carried out, and the extent of the ability of the reclaimed water to meet the needs of the topsoil will be fully ascertained.

2.3 Water-Efficient & Responsible Landscaping Practices

2.3.1 Intent: Minimize the use of potable water for building and grounds maintenance, and avoid using pesticides, herbicides or fertilizers that may pollute the environment.

2.3.2 Requirements

1. Specify 100% of plantings to require low amounts of water and to be pest- and disease-resistant per the BPCPC requirements
2. Use non-toxic pesticides, herbicides, and fertilizers per the Conservancy's requirements.

2.3.3 Proposed Technologies:
The 20 River Terrace project features rooftop gardens on both it's upper and lower roofs. The amount of rooftop gardens significantly exceeds the BPCA guidelines requirements of 75% of all open roof areas (remaining area not used for mechanical equipment).

The concepts of Xeriscape, or landscapes which conserve water, and of sustainable plant-maintenance practices appropriate to the microclimate of the rooftop location, have been followed by the developer. The rooftop gardens have been designed with plant material that requires minimal water and maintenance yet can withstand the rooftop conditions. The plant material includes bamboos, junipers, bearberry, bugleweed, thyme, grasses -- fescues, sedge and reed grass - as well as chocolate vine, honeysuckle, several sedums, wild geranium and Barren strawberry. The developer has indicated that only non-toxic pesticides, herbicides and fertilizers shall be applied as part of an organic, integrated soil maintenance program.

3. SUSTAINABLE LANDSCAPE PRACTICES

3.1 Battery Park City Parks Conservancy Policies

The reclamation of water fits in well with BPCPC's sustainable landscapes practices. BPCPC has developed a wholistic approach to maintaining healthy soil in a natural way to ensure the health and vibrancy of all plant material. Some of their philosophy is based on the work of Dr. Elaine Ingham, an associate professor of botany and plant pathology at Oregon State University and an authority in the area of soil foodwebs. The concept of soil foodwebs is that healthy soil includes organisms that cycle nutrients at the rate and form that plants need; suppress those organisms that cause disease; improve circulation of nutrients, water and air by building soil structure; break down toxic materials; produce plant growth by promoting hormones and chemicals; and create the correct soil chemistry, including pH and elements including calcium, iron, phosphate and sulfur.

BPCPC, under its Director of Horticulture, T. Fleisher, has created the BPCPC's sustainable landscape practices as a practical, wholistic means of horticulture. The main elements are:

1. Use of proper soil management to develop a soil profile specific to location, subgrade, drainage conditions, use, and selection of plant material. Soil

management includes the development of good populations of, and the right mixture of, bioorganisms, including fungal, bacterial, and protozoan matter.
2. Non-toxic means of pest and disease control. Use of alternatives such as beneficial insects and horticultural soaps and oils.
3. Use of water responsibly - cultivation of microorganisms in the topsoil will minimize water requirements, and retain water in root zones to reduce the need for watering.
4. Proper selection of plant material – select plant material that does not require large amounts of water or require chemical assistance. Beyond selection for aesthetics, selection of plant material must be site specific, based on microclimate, including sun orientation, wind levels and adjacent landscape forms, use intended and degree of use expected, and adjacent existing plant material.
5. No use of inorganic fertilizers. Instead, use of compost and natural sources of nitrogen. Biosolids, (waste water sludge), when used as compost, actually breaks down toxins in the soil as well.
6. Continuous soil testing – testing of topsoil and base material regularly and constantly for pH, salt content, and percolation.
7. Proper horticultural practice including proper pruning and planting techniques. For example, trees are not often planted at the right height, at the flair, with the result that oxygen to the roots is cut off.

By following these practices, soil is created that can best nurture the plant material. The careful balance on the topsoil biomass is critical. That is why the salt level of the reclaimed water is so critical - it must support the delicate balance of the topsoil biomass.

3.2 New Park Sustainable Design

Teardrop Park is only one of BPCA's new open spaces built according to sustainable landscape practices. The Site 23/24 Playing Fields also integrate sustainable design. Both of these parks have been designed using BPCPC's standard landscape practices. They both include additional sustainable design elements as well.

3.2.1 Teardrop Park.

Teardrop Park shall have the following sustainable landscape measures:

1. Use of biosolids (waste water sludge) as the organic material of the topsoil.
2. Local materials based- rock outcroppings, boulders, and cut stone from nearby upstate New York. It is the intent that the park will evoke the landscape of upstate New York in its use of rock and plantings.
3. Rainwater irrigation system - oversized piping to retain rainwater for irrigation.
4. Recycling, filtering and reuse of water for water features.
5. Use of water reclaimed from 20 River Terrace for drip irrigation. Most of the landscape will be fed by drip irrigation, with the exception of two lawn areas.
6. Selection of plant material based on microclimate. Teardrop Park is designed to evoke the landscape of upstate New York, but selection of plant material was even more importantly based on the microclimate, one of shade and significant winds. Lawn areas have thus been minimized, and the seed mix has been custom designed to work in the low light, windy setting. Plant material selection has been made to some degree based on the concept of commensalism – selection of plant material that work together successfully in shared root zones

3.2.2 Site 23/24 Playing Fields.

Site 23/24 Playing Fields is over three acres in area and shall consist of two Little League baseball fields and a soccer field and also serve as a village green for the neighborhood. It shall have the following sustainable landscape measures:

1. Creation of bioswales, or drainage channels heavily planted to utilize biological means to filter stormwater/runoff prior to its percolation. In this way, water is retained and taken up by the plants, and pollutants are filtered out. The bioswales will create a "live" edge of the ballfield and eliminate the need for a built barrier and additional drainage piping. Plantings shall be wetland varieties capable of utilizing the water and retaining it within the plant's root zones.
2. Use of photovoltaic cells/wind turbines for portions of the sport lighting.
3. Reuse or chipping of existing plant material that is slated to be removed.
4. Use of Clivus Multrums, composting toilets is being evaluated. Limitations on the
4. number of uses possible are being considered given the density of use projected for such a large, multi-use area.
5. Creation of a "green" trailer for park programming that will use photovoltaic cells to feed equipment, use recycled materials, have insulation with an R value of 30, and use daylighting to minimize electricity needs.
6. Reuse of soil and subgrade within the project boundaries.

4. CONCLUSION

With these building and sustainable landscape practices, the Battery Park City Authority hopes to further work in the use of new, innovative techniques for water use and sustainable landscapes. BPCA is following the progress of 20 River Terrace on its website at www.batteryparkcity.org/chapter1flash/CHAPTER_01_INDEX.htm in the hopes that information learned can be disseminated and built upon for projects that follow in Battery Park City and elsewhere. The Environmental Guidelines are available on the site as well at http://www.batteryparkcity.org/guidelines.htm.

Together these building and landscape projects integrate processes to treat water as the precious, vital resource it is, one that must be understood to ensure it is efficiently used to meet the needs of people in cities and beyond for future generations.

Creating Opportunities for Green Buildings as Infrastructure

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1. INTRODUCTION

It is well recognized that an integrated approach is essential in designing truly sustainable communities. An integrated approach is a multi-disciplinary and seamless assessment of land use, infrastructure and building design issues that develops solutions which addressing multiple issues simultaneously. In this manner extraordinary opportunities are introduced, efficiencies are maximized and redundancies are minimized.

This paper, illustrated by Canadian and U.S. examples of green homes, buildings and neighbourhoods explores such an approach to determine how the role of green buildings could be expanded Following an examination of land use efficiencies it notes briefly some current capabilities of green buildings and then identifies how these capabilities might be optimized and integrated as neighbourhood support systems (infrastructure).

2. NEIGHBOURHOOD ROAD PATTERNS

Road patterns are often overlooked for their potential impact on cost savings, infrastructure and building solutions. A recent CMHC study "Learning from Suburbia: Residential Street Pattern Design"[1] examines numerous street patterns and documents some of the land and cost savings achievable with relatively minor adjustments to these patterns.

This study uses a 400 metre (5 minute walk) square neighbourhood to demonstrate that with the perimeter "high" streets held constant land area consumed for internal streets can range from 23.7% to 36% without a loss of building opportunities. As pattern does not dictate density, density is held constant during this comparison.

	 **Square Grid.** (Miletus, Houston, Portland etc.)	 **Oblong grid.** (most cities with a grid)	 **Oblong grid 2** (some cities, or in certain areas)	 **Loops.** (Subdivisions - 1950 to now)	 **Cul-de-sacs.** (Radburn , 1932 to now)
Percent of area for streets	**36.0%**	**35.0%**	**31.4%**	**27.4%**	**23.7%**
Percent of buildable area	**64%**	**65%**	**68.6%**	**72.6%**	**76.3%**

Fig. 1: Road pattern comparison

	 Square Grid. (Most cities)	 VFG A (4 loops,4 C-D-S)	 VFG- B (4 loops,2 C-D-S)	 FVG- C (8 C-D-S)	 VFG- D (8 C-D-S)
Percent of area for streets	**35.0%**	**27.4%**	**27.4%**	**23.7%**	**23.7%**
Percent of buildable area	**60%**	**63.6%**	**64.3%**	**68.0%**	**68.0%**
Percent of Open Space	Required **5%**	**9.0%**	**8.3%**	**8.3%**	**8.3%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**

Fig. 2: Options for efficient road patterns

Figure 1 above, illustrates this efficiency range. The "recovered" open space of the more efficient patterns generates expanded opportunities for a broader range of building configurations and/or increased densities and/or a mixture of uses acceptable to a broad segment of the population. It is this increased density and use mixture which, in turn, can enhance the viability of buildings to become integrated as infrastructure components.

It is of no small consequence that the most efficient road pattern represents a savings of at least $1,000,000 (Can.) in road and infrastructure cost for this 16Ha neighbourhood. These funds could be saved or used to finance building or infrastructure solutions with potentially higher capital costs but affording better long term savings and paybacks.

Fig. 2 demonstrates how the more efficient grid, loop and cul-de-sac patterns of Fig.1 might be integrated and connected and how green space could then be integrated into the neighbourhood. The short, dead end streets of these options reduce traffic volumes and speeds and thus street widths (and costs) can be reduced even further. A 20% width reduction represents potential savings of about$130,000 (Can.) for the neighbourhood bringing accumulated savings to over $1.25M compared to the square grid pattern The neighbourhood has now has more green space, more varied building opportunities, is far more livable and costs less to develop initially.

The green spaces have multiple benefits. Located within one or two minutes of each home they are safe (observable) recreation and meeting spaces, microclimate mitigators and neighbourhood connectors. As paths and parkettes they are venues for safe, enjoyable pedestrian, bicycle and storm water movement. As storm water system components they add a potential further $325K in savings. As systems of naturalized channels, ponds and wetlands provide wildlife habitat, slower, less damaging water flows, potential on-site water re-use and cleaner discharge these solutions lessen the burden upon and cost of central systems. Savings have now accrued to $1.5M for the neighbourhood and more for the whole community.

3. BUILDING DESIGN INFLUENCED BY LAND USE PATTERNS

Road patterns which generate cost reductions and provide opportunities for less costly infrastructure also provide opportunities for alternate site plan and building designs. Open space and discontinuous road patterns analyzed together generate a greater potential for site plans to optimize/preserve natural site attributes, solar access and perhaps increase density.



Fig.3 Ithaca neighbourhood

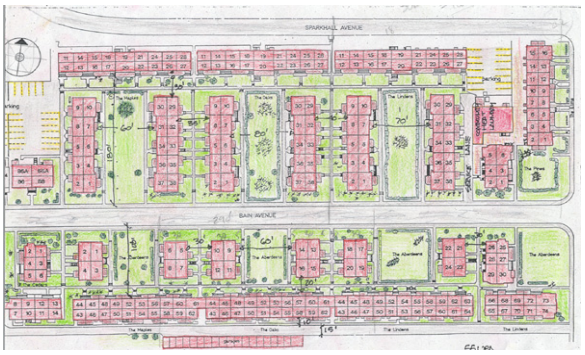

Fig.4 Bain Co-op

In **ITHACA** New York a rural co-housing community has developed their first 30 home neighbourhood (fig, 3) adjacent to a .4 Ha. pond on just 1.21 Ha. of the 71.2 Ha. site. Four other similar neighbourhoods are also planned. Infrastructure costs were 60% lower than those predicted for an earlier development proposal of 150 .8 Ha lots on the same property.

The building designs capitalized on this land use pattern to also effect significant energy savings. The semi-detached homes, designed to optimize solar gain, cross ventilation and natural cooling and to employ a better quality envelope (paid for by some of the infrastructure savings) reduced their energy needs by 75%. Such reduced needs combined with the clustering approach allowed for one conventional domestic boiler to service 8

homes. The boilers distribute hot water to an efficient hydronic floor heating system in each home

Each group of 8 homes locates their shared boiler in a small module on the exterior of one of the homes. This shared, accessible servicing approach provides the potential for maintenance, monitoring, replacement/upgrade without interruption to the dwelling units themselves.

The lessons learned from **ITHACA** can readily be translated to the urban context by integrating such clusters into the neighbourhood green pattern and using their central car free space as safe links in the overall neighbourhood connection network.

The **WINDSONG** community in Langley British Columbia also conserved land and infrastructure, this time by clustering their 34 units along a passively heated glazed street in lieu of around an open courtyard. The project occupies just .8 of its 2.5 Ha site leaving the remainder as wetlands, a salmon bearing creek, community gardens and open space.

This solution also heightened positive social interaction between residents. Children often do their homework outside their unit, quietly observed by both their parents and their neighbours and residents meet in a number of communal spaces for spontaneous and planned activities. This interaction contributes to the stewardship and long term sustainabliity of the community.

In the case of **WINDSONG** overall site density and building costs were consistent with nearby town housing projects. Savings from land development and infrastructure financed the costs of the interior street, underground parking and communal rooms.

Denser projects could be modelled on that of the 1.8Ha, 254 unit, **BAIN CO-OP** (Fig.4) in Toronto. Even at this density, every unit has direct grade access and the project incorporates community composting and gardening, on site rainwater storage and reuse, on site employment opportunities, extensive landscaping and communal facilities. The entire site has been efficiently serviced by a central heating and hot water plant since its construction in 1914.

Another example of green buildings optimizing their sites is **CONSERVATION CO-OP** in Ottawa. This project has the same density as the Bain co-op (135 units per Ha.) but as a four story elevatored configuration it occupies only .625 Ha. The project eliminated its parking garage (only 8 surface spaces were provided) using those funds to pay for an improved building envelope and mechanical systems, roof gardens, recycling rooms, rain water cistern, heat recovery units in all suites, bicycle parking for 200, an infiltration storm water pond, communal greenhouse and gardens etc. Its construction costs were equal to similar apartment buildings built under the same assisted housing program but its energy usage is 22% lower.

It was noted above that overall density for the neighbourhood was held constant for pattern comparison purposes. However as research confirms both that increased density is acceptable to a far greater segment of the population when located in close proximity to open space[2] and that infrastructure costs per unit are lower at higher densities it should be noted that those solutions which *do* provide increased density *in a broadly acceptable manner* are viable approaches to reducing per unit infrastructure costs even further.

4. WHAT GREEN BUILDINGS DO NOW.

Buildings such as the 1996 CMHC **TORONTO HEALTHY HOUSE** (THH) have entirely eliminated their municipal infrastructure requirements. The THH, situated on an inexpensive unserviced city lot, invested some of the $150,000 it would have cost to connect to city services a block away into its own internal water purification/ reuse and waste water treatment systems instead. These systems capture, store and reuse rainwater about five times before discharging it into a tiny on-site dispersal bed. The building design also integrates highly efficient appliances, fixtures and heating into a system which optimizes orientation, glazing and shading, and a high mass in order to obtain 75% of its space heating and much of its electricity from the sun. As a result its annual operating costs are only about $300 per year.

Although the house itself cost about $50,000 above the norm to build, its overall savings when land price and infrastructure costs are factored in were actually about $50,000.

In **EAGLE LAKE**, a remote Ontario community, a simpler house was built, also with independent infrastructure. In this instance the complete infrastructure was provided in a container adjacent to the house. The containerized system, (ECONOMAD™) integrates the Eco-septic and Waterloo bio-fliter™ systems used in the Toronto Healthy House with a co-generation system for power, heat and hot water. The complete prototype module for this single house cost $85,000 replacing potential servicing costs of $75K to$200K per house for watee/wasetwater, $42K hydro and $14K of house mechanicals and construction.

5. WHAT GREEN BUILDINGS COULD DO IN THE FUTURE.

If the site planning and shared servicing approach of **Ithaca** and the intensification approaches of the **Bain** were melded with the design and infrastructure approach of the **THH** or **Eagle Lake** then green buildings could readily progress from self serving to serving others.

The above homes demonstrate huge potential but not necessarily the ideal. Often micro systems find better costs and efficiencies as small, shared systems. An eight home sized ECONOMAD, for example, provides wastewater treatment at $8K to$10K per home, potable water at $3K and the full module at about $30K to $40K (Can) instead of $85K as at Eagle Lake.

Costs of this magnitude will often compete with full municipal system costs especially when off-site plant and environmental remediation costs are included. For some urban sites such as those with difficult site (soil, water, terrain, foliage) conditions this modular approach, which can be used to avoid the tremendous cost and damage associated with trenching, clearing and grading etc. can become a more economical solution. Lower operating costs and greatly reduced environmental impacts raise the benefits further.

6. INTEGRATING BUILDINGS, NEIGHBOURHOODS AND COMMUNITIES

The high streets which border the discussion neighbourhood convey most traffic and services, house commercial and institutional amenities and knit the community together. The scale and nature of these high streets suggests that larger buildings are more appropriate there. Larger buildings can house multiple uses, multiple uses opportune integrated solutions and integrated systems offer the potential of delivering multiple services (such as heat, hot water and power) simultaneously.

Current practice in this regard is exemplified by **2211WEST 4TH. AVE.** in Vancouver. This commercial/residential building's program is described as "a geothermal system that views the building as an energy model whereby the diversity of uses and integration of the users on a common earth base exchange system achieves outstanding energy economics while at the same time ensuring a lesser dependence on the energy umbilical cords to the hinterland resource inventory" (*whew*!) Its energy needs are 35% below model energy code levels.

This is one of many current examples of smaller scaled buildings which supply much, if not all, of their own needs in a responsible manner. As with the single house examples the next step is for such buildings to capitalize upon their efficiencies and to implement cost effective systems that can be shared with their neighbours. These could be water, waste and energy systems of all sorts. Many system components needed for such an approach exist now.

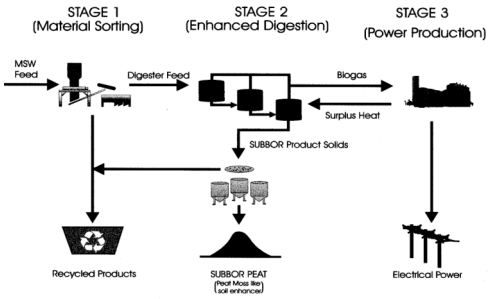

Figure 5: The Subbor system

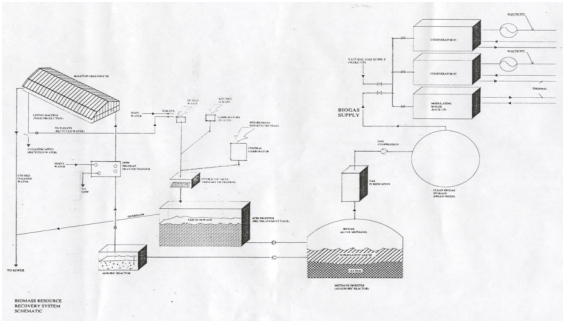

Figure 4: The Ideas Challenge System

The SUBBOR™ waste treatment plant in Guelph Ontario (Fig. 5) receives mixed garbage, processes it internally for 100% recovery as recyclables and compost, recovers methane gas via anaerobic digestion and uses the gas to generate electricity on site. With careful sizing such a facility could be incorporated into the community as part of a larger building(s) replacing the conventional mechanical room(s). Several neighbourhoods might use one building complex to convert their waste resource into energy without the need for extensive transportation or land consumption. The compost could be applied to the green spaces and the recyclables sold or re-used locally.

Another infrastructure component which could become feasible at the neighbourhood scale is the living machine which treats liquid waste through a series of tanks stocked and sequenced to replicate the biological environments of wetlands. After a period of a week or so the process delivers clear, reusable and sometimes potable water. The system requires no chemicals and very little energy to operate. The setting for the process, a sweet smelling greenhouse of plants, fish and water can be a positive aesthetic addition to the streetscape, courtyard, rooftop or building atrium.

Shared energy systems can also become feasible at this scale. There are numerous district plants on campuses and in communities across Canada and the world and their operating efficiency is well established. At a small scale (i.e 30 homes) they generally have prohibitive capital cost (Natural Resources Canada estimates up to $21K/home) However, at larger scales (such as the 254 unit Bain project) the economics become much more viable.
The true efficiencies of all of these systems and others, however, is best realized when they are integrated together and when they are integrated into buildings which house other uses. Buildings have already begun to incorporate them and share them in a limited way.

The 150 unit 13 storey mixed use **TATRY** project in Toronto incorporates a conventional co-generation system to supply electricity for itself and it neighbouring 7 storey, 100 unit **PATHWAY** building. Sharing one plant optimizes this technology.

The 48 storey **4 TIMES SQUARE** N. Y. office tower generates much of its own power with integrated photovoltaics and fuel cells running continuously at full power for best efficiency.

The 1993, 500m^2 **BOYNE RIVER ECOLOGY CENTRE** school near Toronto Ontario integrates a living machine, passive design and several renewable power sources into a school that does not need municipal services.

The **IDEAS CHALLENGE** 14 storey apartment proposal for Toronto (Fig.6) integrates aspects of **Subbor**, **Tatry,** the **Boyne** and **4 Times Square** by coupling integrated photovoltaics and a methane recovery system to a living machine which digests neighbourhood waste to power an on-site co-generation unit to supply two apartment buildings and 75 nearby townhouses. The building would essentially function like a neighbourhood "mother ship" providing housing and neighbourhood amenities while treating some of its waste and supplying some of its energy.

There are other such opportunities. Hospitals have huge 24 hour power needs and currently incorporate the ability to supply them for themselves during emergencies. With green building design the same hospital would have lower needs and could supply its neighbours with the same systems (or better ones) on an ongoing basis. High tech industry buildings currently make huge power demands. Computer technology is undergoing radical change and energy needs are expected to tumble. Were high tech buildings to echo 4 Times square and supply some or all of their power needs themselves this power might eventually become surplus and could become available for neighbourhood distribution when demands change.

7. SUMMARY

There are a number of design options for a mixeduse neighbourhood, some more efficient than others. Efficient land use patterns opportune short and long term cost savings, more efficient, more environmentally responsible infrastructure solutions and building designs and quieter, safer, healthier, more affordable and more livable neighbourhoods.

There are many efficient and healthy infrastructure and building methodologies and designs which have been designed, implemented, tested, assessed, proved and published.

Neighbourhoods which integrate efficient land use and optimal building technologies together can viably create building systems as local, efficient, low impact infrastructure. The resulting efficiencies and savings make the community one which both can and ought to be sustained indefinitely.

[1] CMHC 2000, Grammenos et al
[2] Multiple Housing For Community Sustainability , CMHC 2000, Grammenos et al

An Integrated Planning Based on Sustainability: Towards Resource-conscious Communities in a Korean Rural Area

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1. INTRODUCTION

1.1 Concept of Sustainability

After the 1960's, environmental awareness arose from the growing concerns of natural resource degradation, pollution problems, and disastrous climatic changes such as global warming. These environmental issues and crises were in part due to uncontrolled urban sprawl, maximizing economic profit without consideration of environmental consequences and promoting the unwise separation of land uses. Since the Brundtland Commission's *Our Common Future* in 1987, sustainability has become the great buzzword in topics ranging from architectural detailing to global environmental planning (Steele, 1997).

The Brundtland Commission's definition of sustainable development, '*meeting the basic needs of the present generation without compromising the ability of future generations to meet their needs'* is often considered the benchmark from among more than seventy available definitions in academic fields (Dewan, 1998). This definition emphasizes the idea of duration and continuation through the generations and the importance of quality of life including environmental health, economic well-being, and social equity. While the theory and practice of sustainability presents a diverse range of ideas, there is a consensus on minimizing damage to the existing ecosystem and utilizing natural and human resources at the local scale in order to achieve the concept of sustainability.

1.2 Research Problems and Objectives

The concept of sustainability offers an exciting way to release the pressure for planner/architects from the concept of environmental protection, which has separated human beings from nature, and has imposed painful endeavors to reduce the needs. However, there is still a great gap between the concept and planning means for most planner/architects when they pursue sustainable planning over common practice in development. Problems arise when planning is analyzed and evaluated through non-physical and fragmented procedures used by specialized professionals. This approach lacks spatial translation from/to geographical plans in both directions, and the resource-consciousness to the interrelation between nature and human settlements. In addition, according to most concepts of sustainability, sustainable planning methodologies should recognize resource limits and healthy interrelationships between human activities and natural conditions.

This research explores an integrated way to translate concerns of resource use and material flows in a sustainable community planning method through the development of the Integrated Resource-conscious Planning Method (IRPM). This method consists of a synthetic procedure improving resource flows in community planning, and quantitative techniques for measuring resource use and damage to local ecosystems. Using the IRPM, a prototype village planned for a Korean rural area is proposed and evaluated by quantitative comparisons with a conventional method driven only by marketing-consciousness.

2. DEVELOPMENT OF THE INTEGRATED RESOURCE-CONSCIOUS PLANNING METHOD

The integrated approach in community planning has its roots in ancient agricultural principles. It is therefore not surprising to find similar concerns in the basic principles of IRPM. This approach was widely used in the Far East Asia whose countries were densely populated. They could survive only by utilizing every material and social resource. Because of their philosophical roots in nature and their close connection to the environment, they knew how to use and preserve life-sustaining resources. This system has continued for the past four thousand years since the pre-industrial age (Hilberseimer, 1949). In this research, IRPM has been evolved through the incorporation of modern technologies and their use of resources in local eco-systems.

2.1 Resource-conscious Inventory of Planning Factors

This research focuses on sustainable use of human and natural resources for community planning. This approach does not intend to provide a comprehensive handbook for identifying and dealing with all the potential resource and planning factors. Instead, it assumes that a meaningful inventory can be defined which increases the "conscious use" of resources in a community, and which acts as important factors in the planning process. A limited number of planning factors can clearly and rapidly present results. Based on sustainability in ancient principles and development of environmental management, a set of resource-conscious planning inventory representing a balanced selection between human and natural resources is established. The key factors of natural resource planning are defined as energy, water and air quality. Production, labor, and capital are defined among the human resource factors.

2.2 Ecological Systems Modeling and Integrated Performance Evaluation

Based on the development of the systems approach in business fields, an ecological adaptation of the systems approach, developed by H. T. Odum, explains nature and human settlements as an "ecosystem", the interactive organisms with the flow of energy and matter from sun to final. This view provides the concept of modeling techniques using diagrams to visualize the main flows of energy and matters, where they come in, and where they go out. It assumes any resource in a ecosystem becomes a component of flows, energy turns cycles of other resources including human resources such as capital, production, and labor (Odum, et al. 1976).

Performance evaluation emphasizes efficiency indicating the ratio of resource flows through a system or systems rather than conventional methodologies substitute only economic value for dissimilar value systems used for resources in evaluation. The most important efficiency is the ratio of *"desired output"* to *"all input"* to a certain resource. At the same time, measuring the environmental impacts to the existing ecosystem such as the emissions of CO_2 and air pollutants should be considered as critical indicators of *"undesired output"* to *"all input"*, which threaten the life of a whole ecosystem.

According to the concept of ecosystems, the framework of integrated performance evaluation is related to the ecological systems modeling for resource-conscious community. The framework consists of a combination of modules for analysis. The content of a module can be modified depending on the characteristics of alternatives, accuracy of results, available data or scale of planning. A couple of computer simulation techniques could be selected for contents of modules, especially in an environmental resource analysis at small scales. These can be substituted by validated empirical data if necessary. Figure 1 shows examples of an ecological system model for resource-conscious case and a framework of integrated performance in this research.

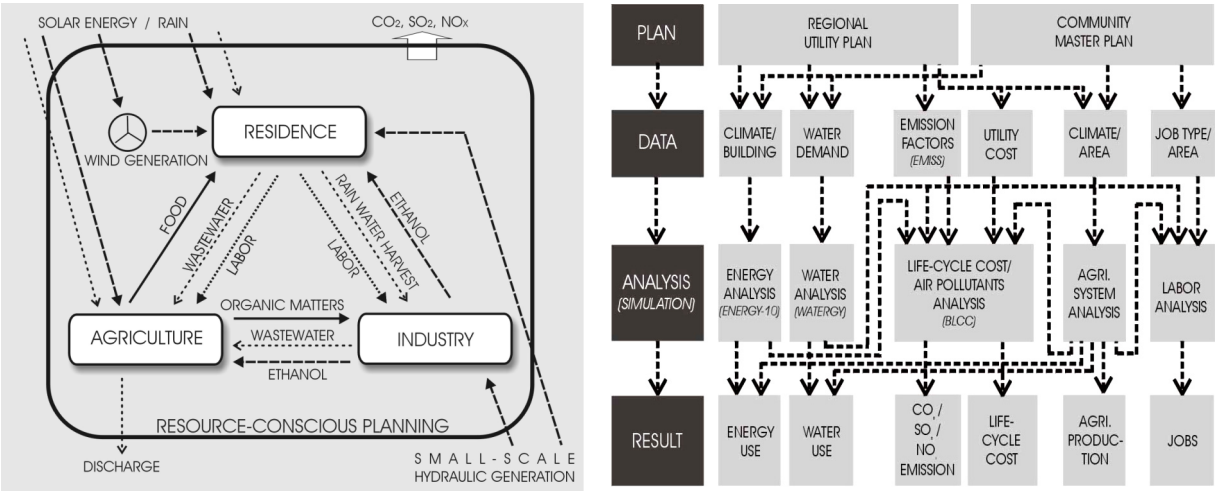


Figure 1 Examples of an ecological system model for resource-conscious case and a framework of integrated performance analysis.

2.3 Planning Procedure of the IRPM

The planning procedure of the IRPM is compared with conventional planning procedure as shown in Figure 2. The major difference with conventional cases is considering the carrying capacity of the site against the population projection. Principal action includes changing the structure of ecological systems rather than adding supplementary systems when the evaluation does not meet the criteria for natural resource limits and of healthy conditions.

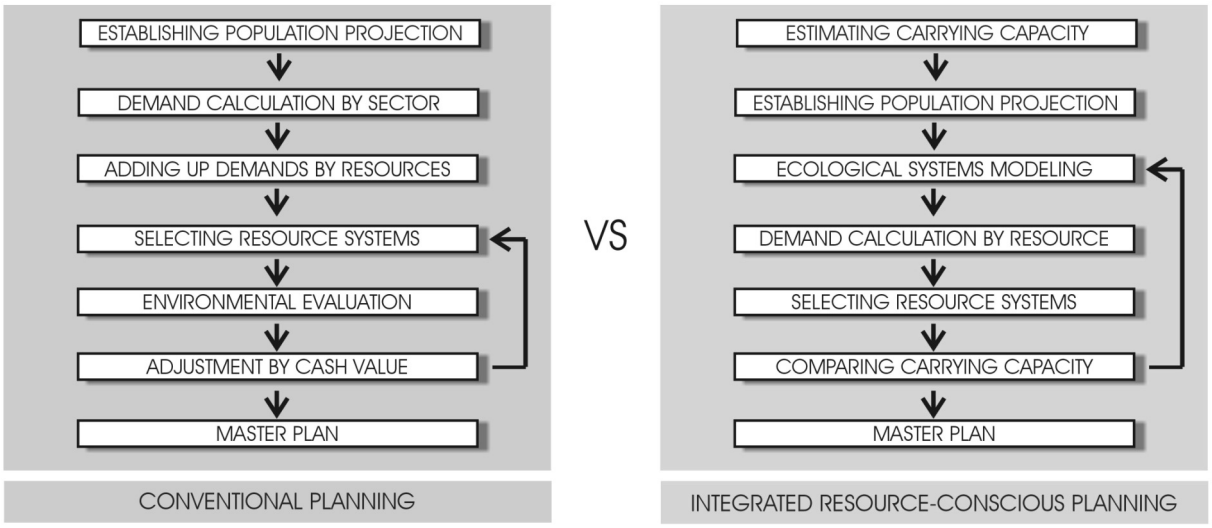


Figure 2 Comparison of planning procedure; conventional planning vs. integrated resource-conscious planning.

3. SELECTION OF SITE AND CASE DESCRIPTIONS

3.1 Selection of Research Site and Conventional Case

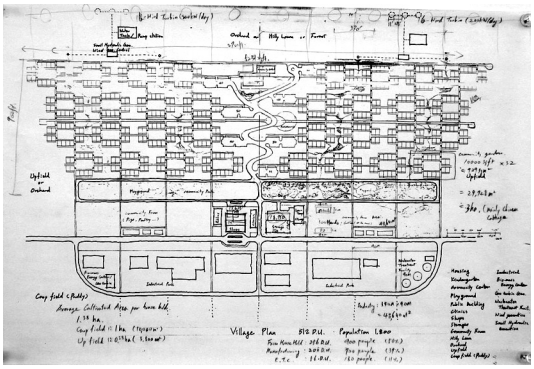
This research is not intended for specific solutions for specific areas, nor for a demonstration of every detail in the real world; rather it is to provide an alternative way of planning concerning uses and relations of resources for rural situation facing rapid urbanization and industrialization. For this reason, a site is chosen, that is located in Paju-Si, a rural town near Seoul that is the Capital of Republic of Korea and whose population is over ten million.

In a conventional case of development, a newly constructed residential development, for a population of about 3,600people, is chosen at Paju-Si, as shown in Figure 3. This attempts to show different results for the performance evaluation. The conventional case is assumed to have as same population and same supporting area including crop fields and forest as resource-conscious case.

3.2 Estimating Carrying Capacity and Resource-conscious Case

Odum (1971) described that "carrying capacity" is the population level for long-range survival and the essence of carrying capacity depends on food production. According to KREI (2000), 2,096kcal of the total daily intake is required for an average adult Korean. In addition, heating energy for housing and minimum energy for agriculture depending on its systems, available technologies, soil conditions, and climate are also necessary. Through the careful investigation on resource-conscious inventory and variable combinations of ecological systems modeling, a master plan of a village that has 1,600people for 601.6ha of land is determined as a prototype village as shown in Figure 3 based on average land area per capita in this region. It aims at self-sufficiency for food, water, and CO_2 absorption, and integration between housing, agriculture, and industry utilizing hilly site conditions.





(a) Conventional case (b) Resource-conscious case

Figure 3 Master plans of conventional case (a) and resource-conscious case (b).

The planning synopsis and systems used for each case are summarized in Table 1 and 2.

Table 1 Planning synopsis in each case.

Item	*Conventional Case*	*Resource-conscious Case*
Land area	601.6ha	601.6ha
Population	1,600people	1,600people
Housing types	Apartments (19~20 stories) 3Br Type A 357units (71.6m^2) 3Br Type B 868units (84.4m^2)	Town house (1 story) 2Br Type A 357units (79.7m^2) 3Br Type B 868units (80.6m^2)

Table 2 Selected resource systems in each case.

Item	*Conventional Case*	*Resource-conscious Case*
Heating and cooling system for housing	Boiler with hot water coils/ Unitary cooling unit	Boiler with hot water coils/ Natural ventilation
Energy performance parameters for housing	Roof R=21.4 Wall R=14.9 Glazing U=0.49	Roof R=38.8 Wall R=26.8 Glazing U=0.26
Energy supply system	Natural gas with grid/ Steam with Gas turbine	Bio-mass energy conversion (ethanol)/ Wind generation/ Solar panel for hot water
Domestic water use	Conventional fixtures and appliances	Water saving fixtures and appliances/ Cisterns for rain water harvest (neighborhood scale)
Storm and wastewater treatment	Municipal storm and sewage drainage and chemical wastewater treatment facility (Discharge to the river)	Open trench drainage with ponds and circular biological plant (Reuse for agriculture and fish farming)
Agriculture	Monoculture crop field (Rice): 298ha (Cultivated by conventional method using artificial fertilizer and pesticide)	Crop field: 110ha (Rotation) Vegetable garden: 4.0ha Animal and fish farms: 4.8ha
Industry	None	Manufacturing complex: 4.8ha

4. RESULTS OF INTERACTIVE PERFORMANCE EVALUATION

The results demonstrate that the resource-conscious case consumes 64% less energy, 57% less water, and emits 87% less global warming gas than the conventional case through the integrated performance evaluation as shown below in Figure 4 and 5.

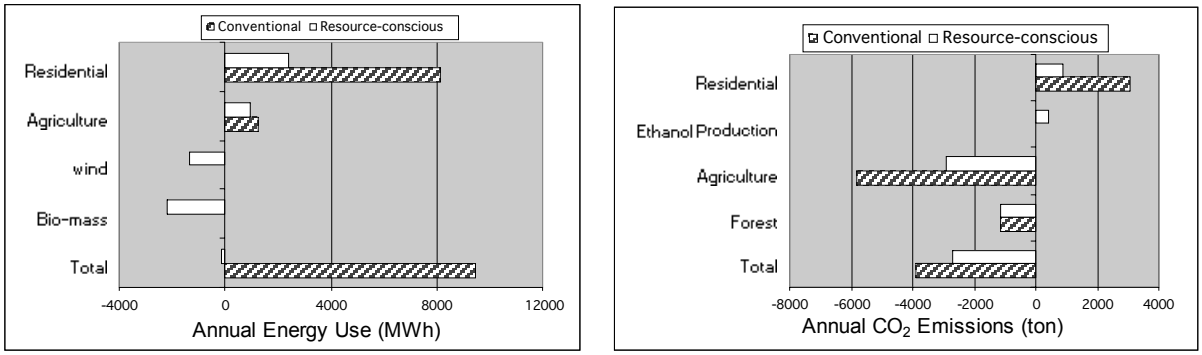


Figure 4 Comparison of annual energy use and annual emissions of CO_2

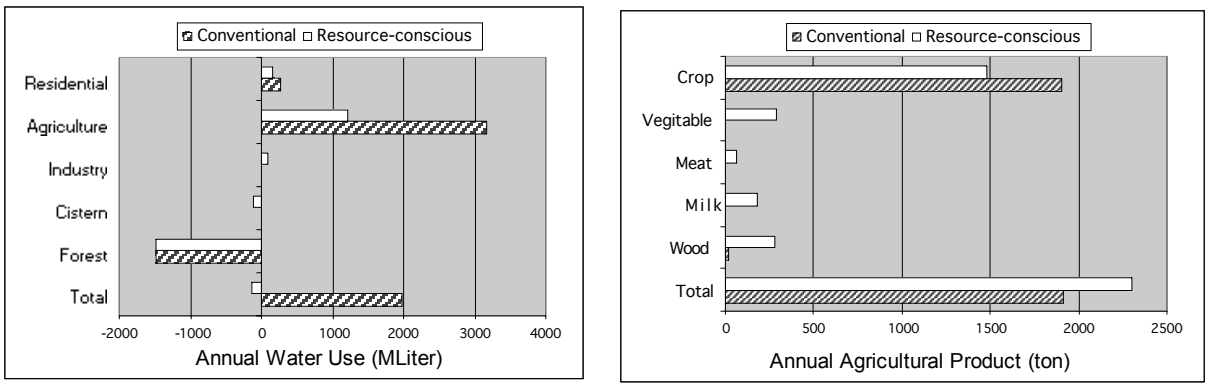


Figure 5 Comparison of annual water use and annual agricultural production.

In this evaluation, energy for industry is not calculated because of the comparison with the conventional case. However, relatively huge amounts of energy needed for the manufacturing complex, which is estimated 18,929kVA, could be provided by small-scale hydraulic generation nearby without use of fossil fuels. In the conventional case, agricultural production is 1,916tons per year and only 469tons are consumed for their community among them. It could provide 110 fulltime jobs for farm households. On the contrary, the resource-conscious case produces 2,297tons per year of various agricultural yields and 1,939tons are consumed for their community among them. It could provide 315 fulltime jobs, 61.5% of full employment in their community. These not only meet 100% of food needs and water needs but also meet the capacity of CO_2 absorption within the community. The analysis of transportation energy and life-cycle cost is not performed in this paper. However, the conventional case needs more capital overlay to purchase fuels, artificial fertilizers, herbicide and pesticides.

5. CONCLUSION

The resource-conscious case is a demonstration of an alternative way how human settlements fit in the local nature as a state of symbiosis against the conventional pattern towards globalized life-styles consuming unlimited resources. However, the future for integrated planning towards resource-conscious communities seems to be far from complete under the current domination of conventional development driven only by marketing-consciousness. IRPM might help illuminating a way to understand current conditions and systems clearly and to find a more sustainable future of our communities in the rural regions and developing countries.

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Iterative Modeling of Stormwater Harvesting Systems for Commercial Buildings

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1. INTRODUCTION

Stormwater harvesting is an effective strategy for reducing potable water consumption in commercial buildings. The strategy consists of applying site precipitation to non-potable water uses within the building and on the building grounds (Texas Water Development Board 1997). Potential applications for captured stormwater include water closets, landscape irrigation, mechanical systems, and other building uses (Ferguson 1998). Captured stormwater volumes have the potential to supply up to 95% of the total building water demand (Stein and Reynolds 1999). In recent years, there has been a marked increase in stormwater harvesting systems due to rising potable water costs and the desire to minimize stormwater runoff in urban areas.

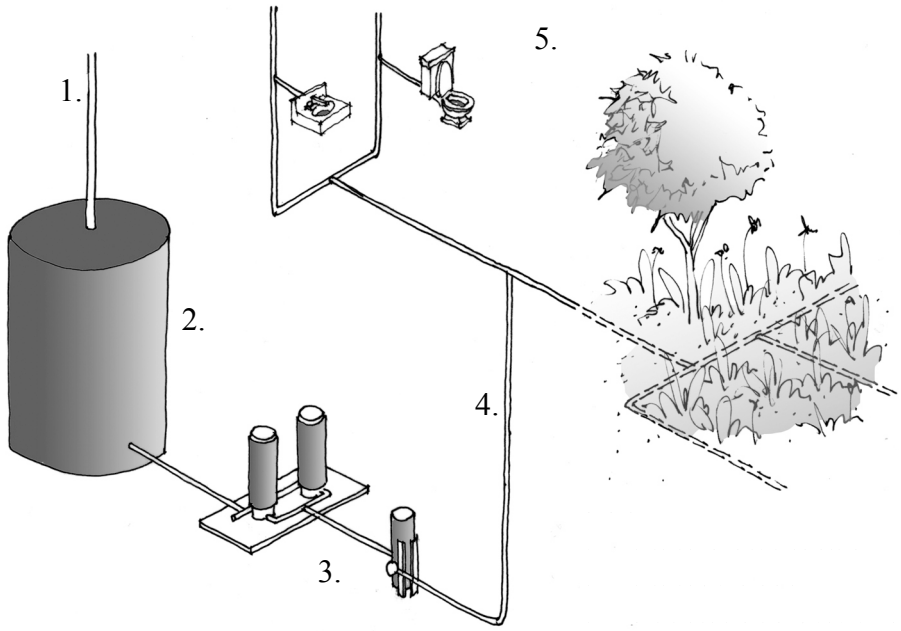
Designing stormwater harvesting systems is challenging due to variable system parameters including stormwater generation and non-potable water demand. An iterative computer model can be used to facilitate the design of these systems. Such a model can perform simultaneous calculations on the variable inputs and outputs of a stormwater harvesting system to determine the most efficient system design.

The intent of this paper is to describe an effective computer modeling protocol to optimize stormwater harvesting systems for commercial building applications. The model utilizes estimated building parameters, historical precipitation data, and anticipated occupancy rates to quantify system variables on a daily basis throughout a typical operational year. The gathered data can then be used to size the stormwater harvesting system properly, resulting in lower capital costs and greater reuse of captured stormwater volumes.

2. DESCRIPTION

Stormwater harvesting systems are designed to reuse captured stormwater for non-potable uses within buildings as well as on the surrounding landscape. A typical system is illustrated in Figure 1. Such systems can be summarized as four general components: the catchment area, the collection system, the storage tank, and the supply network.

The catchment area is the total area where precipitation falling on the site is captured for reuse. In most cases, the catchment area is equivalent to the roof area of the building. The catchment area might also include other constructed surfaces such as roads, parking lots, sidewalks, and patios. Catchment area surfaces should be carefully selected to avoid polluted surfaces that might contaminate the stormwater. For instance, roofs with wood or asphalt shingles and highly traveled roadways may produce runoff that is unsuitable for reuse.



5. Final Use(s)

Figure 1 Standard Components of a Stormwater Harvesting System

After stormwater volumes are generated in the catchment area, they are directed to the collection system. The collection system consists of gutters and downspouts to transport stormwater volumes to the storage tank. Additional components of the collection system might include site stormwater features such as curb and gutter systems or swales. The collection system often includes gross treatment mechanisms such as leaf screens to remove larger contaminant particles from the captured stormwater volumes.

The collection system transports the captured stormwater volumes to the storage tank, which is the heart of the stormwater harvesting system. The storage tank is located in the basement of the building or underground on the site and is typically made of concrete, fiberglass, metal, or plastic (Texas Water Development Board 1997). Figure 2 provides an illustration of a typical storage tank in a stormwater harvesting system.

The storage tank is designed to regulate the tank holding volume between a minimum and maximum storage level. If the captured stormwater volumes exceed the maximum tank level, excess volumes are discharged to the storm sewer. Conversely, when captured stormwater volumes are depleted and the minimum storage level is not maintained, potable water is automatically added to the storage tank. A float system is used to regulate the maximum and minimum storage levels in the tank. To prevent backflow into the potable water system, an air gap is typically designed between the potable water supply and the storage tank.

After the captured stormwater has been stored in the storage tank, it is delivered to end uses in the building and on the building grounds via the supply network. Non-potable water uses often include water closets, irrigation systems, showers, custodial sinks, laundry machines, and mechanical applications such as evaporative cooling systems (Stein and Reynolds 1999).

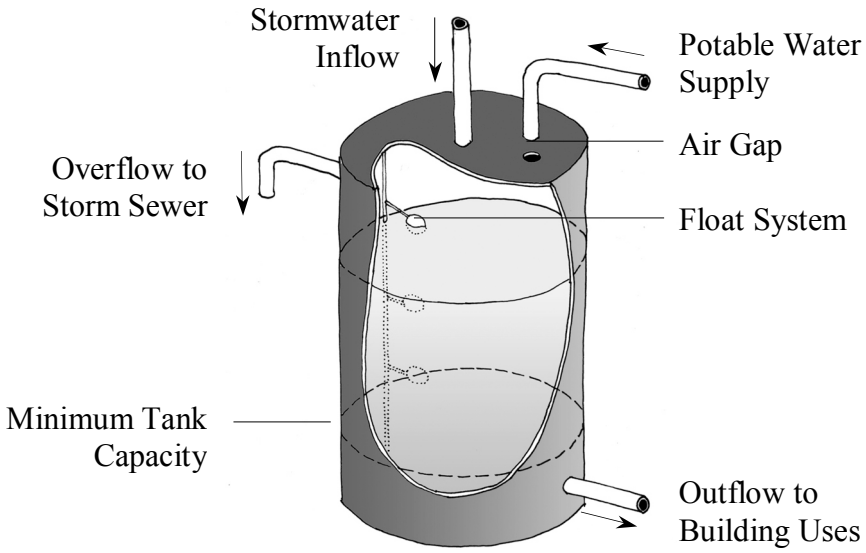


Figure 2 Typical Storage Tank Details for a Stormwater Harvesting System

Booster pumps are used to deliver the captured stormwater volumes to their points of final use as well as provide adequate water pressure. The supply network also includes a filtration device to remove sediment and contaminants from the captured stormwater. Some systems provide further water treatment such as chlorination or ultraviolet radiation. The level of treatment required is dependent upon the desired end use and local regulations. For outdoor applications, minimal treatment is typical while for indoor applications, filtration is often required and disinfection may be desirable (Texas Water Development Board 1997). A piping system, separate from the potable piping system, is used to deliver the captured stormwater to its final end use.

3. ITERATIVE MODEL

The storage tank is usually the largest investment in stormwater harvesting systems due to the cost of the tank and the mechanical design involved. As a result, special attention should be paid to design the storage tank properly. The storage tank is also the most challenging system component to design. If the tank is sized too small, the system will not utilize as much stormwater as it potentially could. If the tank is too large, the cost of the tank may be prohibitive and an inordinate amount of space may be needed to house it. Ideally, the optimal tank capacity provides the highest percentage of stormwater runoff reuse for the smallest and least costly storage tank.

To determine the optimal storage tank size, it is helpful to use an iterative computer model. The modeling method described in this section follows the environmental modeling protocol as described by Ford (1999). The model is illustrated as a series of inflows and outflows as shown in Figure 3. Stormwater and potable water volumes flow into the storage tank while overflow stormwater and stormwater volumes applied to building uses flow out of the tank. The computations of the model are rather involved because stormwater inflow is a function of variable precipitation events while the building uses are a function of time-based occupancy patterns. As a result, a simple spreadsheet cannot be used to size the storage tank.

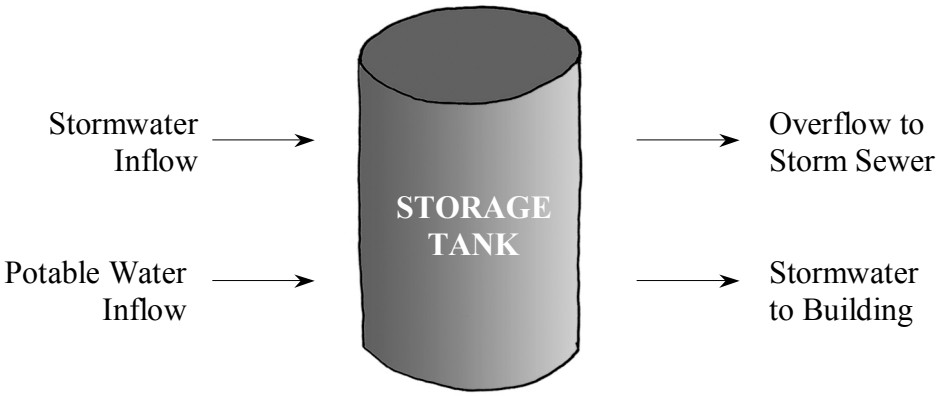


Figure 3 Storage Tank Inflows and Outflows for the Interactive Computer Model

The iterative model is designed to consider all of the system variables simultaneously to determine the optimal storage tank capacity. To demonstrate the iterative computer model, an example three-story commercial office building in Austin, Texas, USA was considered. The example involved a stormwater reuse system to capture stormwater runoff volumes from the roof and then apply these volumes to water closets within the building.

The example building is three-stories with a building footprint of 930 m^2 (10,000 ft^2). The catchment area is equal to the building footprint. Catchment efficiency depends upon the catchment surface, the type of collection system, and regional conditions. Typical catchment efficiencies range from 75% to 100% to account for losses due to spillage, evaporation, and infiltration (Texas Water Development Board 1997). For this model, a catchment efficiency of 90% was used to represent a metal roof with gutters and downspouts. Daily precipitation data for the site was used for an average precipitation year. Occupancy parameters were estimated for the building type, fixtures serviced by the stormwater harvesting system, and building hours of operation. Building and occupancy parameters used in the example are summarized in Table 1.

Table 1 Example Building and Occupancy Parameters

Building Parameters	
Location of the Building	Austin, Texas, USA
Catchment Area	930 m^2 (10,000 ft^2)
Catchment Efficiency	90%
Occupancy Parameters	
Maximum Occupancy	150 persons
Water Closet Flush Volume	6 L (1.6 gal)
Water Closet Visits per Occupant	Once every 2.5 hours
Building Hours	Monday to Friday - 8:00 am to 6:00 pm
	Saturday - 8:00 am to 1:00 pm
	Sunday – Closed

The computer model for the example was designed to run on a daily basis over a typical year. A range of storage tank capacities was tested, from 10,000 L to 80,000 L. The model tracked data on daily volumes of stormwater captured, the water level in the storage tank, the

stormwater volume applied to building uses, the stormwater released to the storm sewer, and the makeup potable water needed to maintain a minimum storage volume.

At the end of the annual cycle, the tracked volumes were summarized and the stormwater efficiency of the system was calculated. The stormwater efficiency is equal to the annual volume of stormwater applied to building uses divided by the potential volume of stormwater that could have been applied to these uses. The potable water efficiency is defined in Equation 1. For the example, the stormwater efficiency is the percentage of captured stormwater that was applied to flushing water closets over the total water closet demand. A higher stormwater water efficiency value indicates greater reuse of captured stormwater and lower potable water use.

$$\text{Stormwater Efficiency [\%]} = \frac{\text{Annual Stormwater Volume Reused [L]}}{\text{Annual Reuse Demand [L]}} \times 100\% \qquad (1)$$

Stormwater efficiency was then plotted for the range of storage tank capacities tested in the example, as shown in Figure 4. The Figure indicates that stormwater efficiency increases as storage tank capacity increases. In other words, a larger storage tank allows for greater stormwater reuse. However, after the storage tank capacity exceeds a specific capacity, the increase in stormwater efficiency slows significantly. In essence, the model reaches a point of diminishing returns with increasing storage tank capacity. The dotted line superimposed over the plotted data points illustrates where the stormwater efficiency no longer increases at an appreciable rate. The optimal storage tank capacity is located where the stormwater efficiency begins to slow, as indicated by the arrow on the graph.

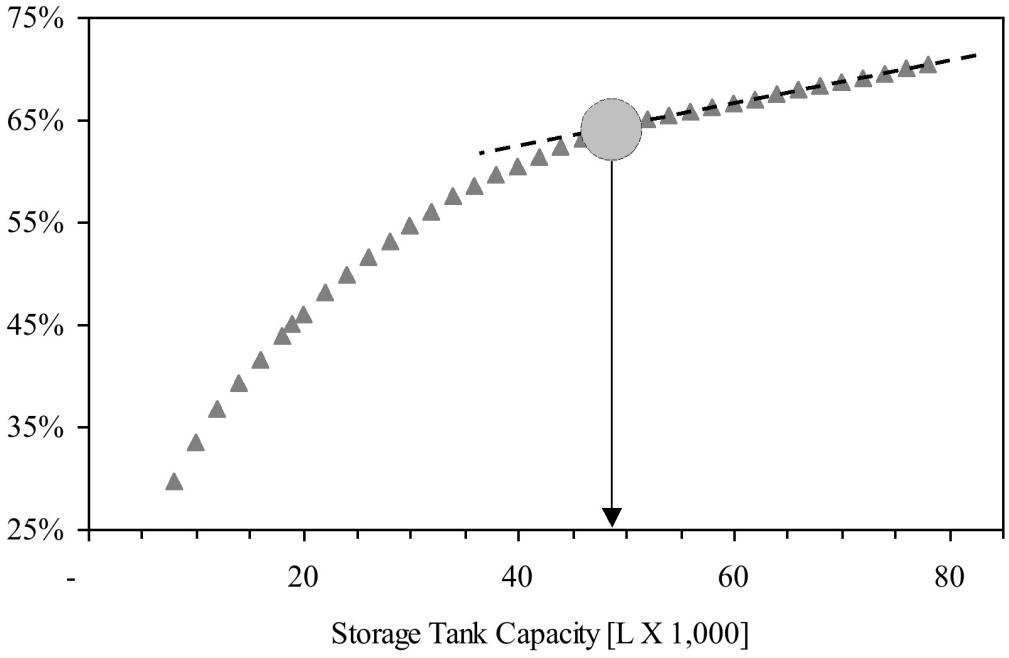


Figure 4 Example Stormwater Efficiency versus Storage Tank Capacity

The Figure indicates that the optimal capacity of the storage tank for the example is 48,000 L (12,700 gal), which is equal to a stormwater efficiency of 64%. This means that 64% of the

water used in the water closets is captured stormwater and the remainder is potable water. This results in an annual potable water savings of 610,000 L (160,000 gal). A larger storage tank could be used in the system but the additional tank cost and space required would only result in minimal stormwater efficiency gains. Conversely, a smaller storage tank could be used but the potential for stormwater reuse would not be fully realized.

The presented model is flexible and can be applied to any stormwater harvesting system. Variables required for the model include the size of the catchment area, catchment efficiency, daily precipitation for a chosen year, daily non-potable water demand, minimum storage tank capacity, and maximum storage tank capacity. All of these variables can be modified on demand to design an optimal system. Not surprisingly, the most time consuming task of the modeling procedure is to locate appropriate precipitation data and to estimate occupant non-potable water demand.

It should be noted that the model only provides an optimal tank size from a systems perspective. The actual size of the storage tank selected may be different than the calculated size due to space availability, economic considerations, available tank sizes, and the potential for additional reuse opportunities in the future. While the calculated size of the storage tank is an important consideration, other considerations will also influence the storage tank capacity for a stormwater harvesting system.

4. CONCLUSION

This paper illustrated the use of an iterative computer model to size the storage tank for a stormwater harvesting system in a commercial building. The model considered the annual performance of such a system on a daily basis over a range of storage tank capacities. The optimal storage tank capacity was found where the stormwater efficiency was maximized with respect to the storage tank size.

This model is useful to size the storage tank properly and to avoid cost and space issues with stormwater reuse systems. When properly applied, such a model can save potable water volumes as well as reduce capital costs of such systems.

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Building Biomimcry
Emulating Nature in our Architecture and Cities

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Janine Benyus, in her book *Biomimicry, Innovation Inspired by Nature*, identifies a few innovations in building materials that could result from our modeling the natural world. "Solar cells copied from leaves, steeling fibers woven spider-style, shatterproof ceramics drawn from mother-of-pearl." But Benyus's argument has implications for the built environment that go beyond material science. Near the beginning of her book, she lays out "a canon of nature's laws, strategies, and principles" that has implications for architectural and urban form. This paper will consider the nine "strategies" she identifies in terms of how we might design buildings and zone cities in ways that would be more environmentally sustainable. None of the ideas here are new. All of the technology and techniques exist to achieve these ideas. What has been lacking is an overall vision of how all of these architectural and urban strategies relate. Benyus's idea of "biomimcry" provides that connection. By looking at how nature has evolved into a network of highly elegant and complex interrelated systems, we have a model of how we might change the ways in which we live and work to be more attuned to the natural world of which we are an integral part.

Benyus describes the nine principles of nature in this way: "Nature runs on sunlight … uses only the energy it needs…fits form to function…recycles everything…rewards cooperation…banks on diversity…demands local expertise…curbs excesses from within…(and) taps the power of limits." Before we look at each one, we should note some relationships among these ideas, grouping them into categories that relate to the four fundamental constituents with which we create and maintain the built environment: space, time, matter, and energy. Fitting form to function and demanding local expertise both involve spatial strategies, connecting or bounding things within a particular place. Meanwhile, recycling everything and rewarding cooperation necessitate seeing the built environment over time, looking at what happens to materials after their current use has ended or at what happens to the cooperative arrangements that evolve. Banking on diversity, curbing excess, and tapping the power of limits all relate to material decisions: the variety of materials we bring together, the total amount of materials we use, and the benefits that can accrue from accepting their limits. Finally, running on sunlight and using only the energy needed both, obviously, involve energy strategies: the source of energy and the amount needed.

At the same time, Benyus's nine principles also apply to a range of scales in the built environment. She mentions building materials and systems, but nature's principles relate to the scale of the whole building, the neighborhood, and the entire city. However, as in nature, some become more dominant at one scale or another. The first four she lists – running on sunlight, using only the energy needed, fitting form to function, and recycling everything – apply primarily to the building scale and secondarily to the urban scale. The latter can only facilitate or obstruct

these principles. The next five principles apply more to the urban scale. Rewarding cooperation, banking on diversity, demanding local expertise, curbing excesses from within, and tapping the power of limits all involve the relationships among individuals or groups of people in a more social or political context. Again, buildings can facilitate or obstruct this, making cooperation among neighbors, for example, more difficult. But the urban scale predominates.

The idea of a built environment that mimics nature demands letting go of a world view in which we seek to dominate and control nature, an idea embedded in our architecture and built landscape. Instead, it requires that we learn from nature and seek an order akin to it. What follows are some preliminary thoughts about this:

Nature runs on sunlight

When you fly over cities, you can't help but notice the tremendous amount of space taken up by the opaque roofs of buildings, all of which keep out the sunlight and use artificial lighting to illuminate the space within. As a result, we have become dependent upon fossil fuels or nuclear power to provide the electricity to do what the sun, on the other side of the ceiling overhead, does anyway, with a better spectrum of light, no pollution, and at no cost. A building that models itself after nature would have a roof that lets in enough sunlight to eliminate the need for electric lighting during daytime hours, properly shaded to reduce glare and unwanted solar heat. It would also have sufficient photovoltaics on the roof surface to store enough electricity to use during the night or for appliances day and night. Buildings taller than one floor would apply the same methods, with floor plates narrow enough to ensure that all areas have access to adequate daylight, and with photovoltaic cladding to provide enough power for electrical needs. We know that people feel and think better, and have better physical and mental health, when in contact with sunlight and the cycles of day and night. Yet we still often design buildings to maximize the proximity and efficient movement of people or goods, creating vast floor spaces far from sunlight. This principle of nature raises a question of just how "efficient" this is. With the knowledge, wisdom, and creativity of people as our most important asset, creating a built environment that helps us live and work at our fullest potential also becomes the most efficient thing to do. We evolved living in sunlight and the built environment needs to evolve in the same direction.

Nature uses only the energy it needs

Look to the edges of cities, often by rivers or waterfronts, and you see power plants generating power used to heat and cool buildings. At the same time, you often see factories that themselves often generate heat and recreational areas that take advantage of the natural cooling of the wind over water. Biomimicking architecture would connect the dots among these things. Instead of generating power for heating in one building and giving off waste heat in the adjacent one, we would link the building generating waste heat to those few that needed heating above and beyond that captured through the solar heating of its own surface and mass. At the same time, biomimicking design would locate buildings in optimal ways to take advantage of natural cooling, with cross ventilation and with air drawn over cool water and up through a building via a stack effect. The size and functions of buildings in the city would also be determined according to its heating and cooling needs, with solar and wind access protected by law. These strategies see the often-unseen energy of the sun and the wind as a resource that we need to design with and around, something often overlooked in the functionalist zoning of buildings and cities. Yet such zoning, be it within a building or a city, confuses two different meanings of function – as an "activity proper to a person, thing, or institution" and as "a factor related to or dependent upon

other factors." By focusing only on our activities, and attempting to separate them accordingly, functional zoning eliminates other factors, such as the energy that makes these activities possible in the first place. A truly functionalist zoning would begin with the factors that sustain the built environment – such as energy – and let activities evolve around them, as happens in nature.

Nature fits form to function

The same confusion exists in the relation of function and form. The idea of form fit to function has received a bad name in architecture because of its frequent misinterpretation by the Modern movement, where simplistic forms enclosed single functions, creating a dull, oppressive environment, the opposite of nature. An architecture of biomimcry would fit forms to multiple functions, since, as so often happens in nature, nothing has just one purpose. Its efficiency lies in the multiple roles every part plays as predator and prey, structure and skin, and so too would we see building efficiency in this way. Thus, fitting form to function in this sense would create an architecture whose spaces allow a variety of uses, amply evident in vernacular architecture around the world. In the North America and Europe up to the 18th Century and in many cultures even today, rooms had multiple roles, as places to sleep at night, to eat and socialize in the morning and evening, and to work during the day. With the adjustment or rearrangement of furniture and the bringing out or storing away of coverings or utensils, people can transform space according to their needs, demanding a fraction of the space demanded by the specialized functions of rooms for sleeping, eating, socializing, and work. Forms that best fit such multiple functions have certain attributes. They are generally square or rectangular, with a length usually no longer than twice the width; have ample daylight from at least two sides, to provide enough light and ventilation; and have plenty of storage to allow for the transformation of the space through the taking out and putting away of the "props" we need to live and work. The forms that fits the full range of human functions, then, are somewhat generic, the opposite of the highly individualistic spaces created in the name of "functionalism" in Modern architecture. Rather than give up on fitting form to function, as has happened in our "post-modern" era, we need to rethink what we mean by function, and fit form to that.

Nature recycles everything

The recycling of consumer products – newsprint, aluminum cans, and the like – has become common, but it remains a rarity among building materials. We still mostly design buildings by creating forms and spaces and bringing new products to bear in their construction, with little or no attention to what will happen when the use of the buildings change or when the building itself is no longer needed. It is as if we conceive of architecture as frozen in time, at the moment of its birth, and care not at all for the previous life of what we bring to the site or the life and eventual death of what we have created. Biomimicking buildings would seek not only to recycle everything, but also to arise from completely recycled materials. That inverts the design process as we now think of it: instead of starting with a form and bending the material world to it, we would start, as humans once did all the time in making shelter, with what we can salvage or remanufacture from existing materials and creating assemblies with that – a process demanding creativity of the highest order. At the same time, we would detail these assemblies in such as way as to allow those who follow us and who have different purposes for the space we create, to disassemble and reuse or recycle everything we have made. That means that building assemblies need to keep their constituent parts articulate, overlapping or butting them together, and connecting them with exposed fasteners, easily undone. This runs counter to the goal of integrating materials in assemblies and disguising their connections so prevalent in today's

construction, yet the latter makes recycling difficult and expensive and it contributes enormously to the accumulation of materials in landfills. If designers have created this problem, we have it within our ability to change it simply by what we use and how we put it together. Nature recycles everything because waste for one is a resource or fuel for another. We need to recognize the value of that in our own work.

Nature rewards cooperation

Private property is a human artifice, overlaid on a landscape of complexly interrelated elements that know few absolute boundaries. And yet we have designed our cities with this artifice as the governing principle, producing urban environments in which competition prevails and sharing rarely occurs. The irony here is that we have used nature as a justification of this, seeing the competition among animals and plants for food and other resources as akin to our competition for private property. Only now we know that for every competitive action in nature, there also exists a cooperative one, and that a healthy ecology is one in which species achieve a balance, some waxing, others waning, but all inseparable from the whole. Were human communities to model themselves after this principle of rewarding cooperation, we would maximize the sharing of things and minimize privacy to that which we cannot do in groups, such as studying, sleeping, personal hygiene, making love. Such an idea, of course, raises in the minds of many the specter of communism, which was anything but modeled on natural principles. It sought to distribute private property more equitably, but still saw the world in terms of competition for resources. A more appropriate analogy would be small, spatially bounded communities in the more distant past, where limited resources and human labor demanded that people cooperate in order to survive. In this light, a community that rewards cooperation is not a radical idea, but a deeply conservative one, in the best sense of that word – a community in which people look after the good of the other and of the whole, and see this as the best way of looking after themselves. Such a community would see individual "property" as part of larger wholes, with fluid boundaries between one piece of property and another. To a culture like ours, so imbued with the idea that private property brings peace and that sees the state of nature at constant war with itself, as Thomas Hobbes put it, a cooperative community seems foolhardy, impractical, and possibly dangerous. But that is because we don't reward cooperation. Were we to do so, providing incentives for cooperative behavior and disincentives for competitive behavior, we would see that we are like any other species in nature, other than the pretense that we somehow are different.

Nature banks on diversity

Just as we base the design of our cities on private property, so too do we zone our cities into separate uses – residential, commercial, industrial, recreational. This applies, to cities, the same thinking that creates agricultural monocultures, where we have taken the diverse plant types of forests and prairies and reduced them to a single chemically controlled species, exposing our food supply to disease, our soil to erosion, and our groundwater to pollution. While the same effects are not as visible in the monocultures we create in cities, they exist nevertheless in the various social maladies that emerge from our ghettos, rich and poor, in the slow erosion of community and identity in our neighborhoods, and in the accumulating pollution of our air as we travel to and from one single-use district to another over the course of a day. A biomimicking community would zone itself to purposefully mix functions, with living and working, commerce and craft, creation and recreation in close proximity to each other. As in an ecology, every part of the city would have roughly the same mix of production and consumption, recreation and recycling, although some will be more dominant in one or the other, with some areas on the rise and others

on the decline in a mosaic of cycles, characteristic of nature's ecologies. This goes against the idea that we have to separate functions in cities for reasons of health, safety, or peace. Yet this complex mix of activities has characterized cities for most of human history, with noxious uses treated as exceptions rather than as the reason to distort the rest of the city to accommodate them. Also, a diverse mix of activities tends to limit the scale or amount of noxious behavior, just as weeds or pests have an almost impossible time getting established in nature, defeated by the density of other cooperating species. Were we to bank on diversity in our cities, we would find the same thing. This suggests, as well, a new role for the urban designer, not as someone who separates and neatly orders a city, but as one who creates the incentives to allow for the right amount of diversity within every part of the city, encouraging new infusions of activities in neighborhoods that have declined and preventing any one function from having too great a dominance in any one area. The urban designer becomes, in this sense, not an agriculturalist, creating and maintaining monocultures, but a gamekeeper, providing the right conditions within which diversity can naturally flourish.

Nature demands local expertise

In her book *The Economy of Cities,* Jane Jacobs argues that healthy regional economies engage in a process that she calls "import replacement," which builds local expertise in the production and service skills that the region once brought in from outside. In her most recent work on "the economy of nature," Jacobs links the idea of import replacement to the way in which ecologies continually evolve new adaptations to sustain themselves. Jacobs's ideas about cities, ecologies, and local expertise have run counter to the trend toward national franchises, global money flows, and regional specialization, and yet her vision may turn out to be the only sustainable alternative as distant corporate executives make decisions that leave many communities vulnerable to sudden and dramatic economic change. An economy derived from biology would, instead, focus on developing locally owned companies, diversifying the local economy, and enhancing the use of local materials and skills. This depends upon a new kind of education, one that studies the local climate and conditions while at the same time teaching local residents the skills needed to replace imports with locally-generated products and services. The latter may not be, at first, as well done as that available for import, but a healthy city-based region accepts that as a short-term trade-off for what it gains over the long run: a highly skilled labor pool able, like a healthy ecology, to adapt to almost any external setback or stress. In terms of the built environment, that means the development of local craft traditions, the use of locally grown or made materials, and knowledge of local climatic and soil conditions – all used to guide how, what, and where we build.

Nature curbs excesses from within

This principle, when applied to human ecologies, also depends a great deal upon education. All too often, education, especially at the higher levels, has become vocational, training students for particular careers. While a place for that exists, especially when focused on the import replacement just discussed, an even more important task for education in an ecologically balanced community entails the teaching of self-restraint. Modern education often does just the opposite, encouraging competitiveness and extreme positions, attitudes that students see modeled in many their own professors. But the liberal-arts tradition of higher education has historically modeled a very different ethic, one focused on developing stoic resolve, self-restraint, and the ability to endure hardship – all necessary in lives lived closer to nature. To sustain healthy communities, we need such an education. That does not mean that nothing extravagant can exist

or that no new ideas – often excessively stated at first – can flourish. Nature has ample examples of the florid and of dramatic change. But excess as an end in itself amounts to wastefulness that a natural ecology – and a human one – cannot long sustain. For the built environment, the curbing of excess from within would result in architecture in which modesty and self-effacement prevailed, with forms that have evolved to use materials and space in the most efficient and elegant way. The necessary breaks from such self-effacement would involve temporary excesses – festivals, fairs, parades, and the like – that give a holiday to self control, without denying the latter's centrality in binding the human ecology and physical community together.

Nature taps the power of limits

This final principle of Benyus's appears the most quixotic, since it links two ideas that seem opposed to each other – power and limits. In most modern cultures, limits on our actions appear to dampen our power, while those who have power seem to have relatively few limits, beyond those of the law, on how and where they live. Yet in nature, there is no power without limits and always limits on power, since the excessive growth of one species over all others leads to the paradoxical result of the species becoming ever more vulnerable to disease or pests or exhaustion of nourishment, and eventually dying back. In a human community, the power of limits often takes the form of participatory democracy, where the power to make physical change occurs within the limits of open debate, widespread consulting, and the building of consensus. Change takes longer in such conditions as it does in nature, where sudden change almost never occurs within ecology short of some external shock. So what is the power of limits Benyus alludes to? In human ecologies, it arises in a distinction the historian Isaiah Berlin once made between negative and positive freedom. Negative freedom, which he defined as freedom from constraint, has become the common way in which our culture thinks of it, and as such, the fewer limits we have on ourselves, the more power we think we have. Positive freedom, the freedom to act within limits, received Berlin's strongest criticism, and yet that idea defines the power of a sustainable community. It accrues not through unlimited growth or domination of others, but by living within its means and creating within constraints. In terms of the built environment, putting limits on the physical growth of a city, on the height of buildings, on size of properties, and on the extent of any one function in a neighborhood – conventionally thought of as a constraint on one's freedom or "property rights" – in fact become ways in which a community can sustain itself and ensure a balance that gives it staying power.

Janine Benyus says that there are "not one but many biomimics … people working at the edges of their disciplines …where ecology meets agriculture, medicine, materials science, energy, computing, and commerce." Notably missing are architects and urban designers. And yet our field has both much to learn from and contribute to the biomimicry movement, whose focus on "the fact that we face the same physical challenges that all living beings face – the struggle for food, water, space, and shelter in a finite habitat" has a particularly architectural cast.

Humanity: The Missing Element of Sustainability

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PROBLEM

How do we consider the needs and desires of humans in the design of their built environment? Often their needs are considered only indirectly as ecological factors such as sources of waste or as economic factors such as levels of productivity, but rarely as goals in themselves. Because the concept of sustainability is based on the interrelationships among *all* factors of the greater environment, it is essential to have the human element equally represented. Progress has been made to relate the economic and ecological costs and benefits of particular building strategies through various measurement tools. Now it is necessary to incorporate human environmental needs into the equation.

One reason why these needs are not yet incorporated is the inherent complexity of comparing the economic, ecological and human factors simultaneously and easily. Whereas a strictly linear analysis in one dimension or a graphical analysis in two is inadequate, with the addition of a third dimension we can include the human element. Conceptualizing in three dimensions is already a skill for most architects. This paper proposes a way to take advantage of our spatial visioning acumen and apply it to a more comprehensive analysis of factors related to sustainability.

Another reason human factors are ignored is the perception that without being able to quantify their direct effects on the environment, their efficacy remains suspect. However, it is important to avoid the pitfalls of relying on the apparent precision of discrete numbers; numbers that are abstracted into a simple average and thereby lose their connection to their source data. For example, the "science-based" information compiled by the BEES system (Lippiatt et al., 2001) is sifted through levels of subjective weighting before determining a performance score that combines ecological and economic considerations; and in the process the resulting quotient is severed from its calculations. Humans are not limited to this linear, sequential reasoning method. Instead, we hold a superior capability to reason spatially. In three dimensions the relationships between a strategy and its factual basis and among parallel strategies are maintained and may be presented graphically. This third facet of the decision-making process that I propose adding can be referred to as "euthenics."

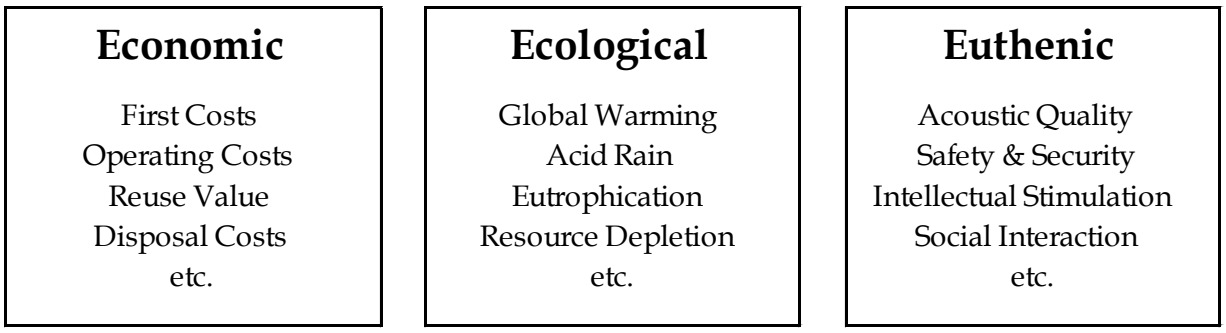

Figure 1 Suggested criteria for each axis of consideration.

DEFINITION

Euthenics (from the Greek *euthenein*, to flourish) is defined as the study of modifications to the environment to improve human functioning and wellbeing. Where the term "ergonomics" usually applies to the working environment, euthenics extends to all human environmental areas. The psychologist Abraham Maslow (1968) mapped human needs onto a pyramid, where the basics of food, clothing and shelter lie at the base and the more enlightened human desires rest at the top of the hierarchy. The limited definition of a building as mere "shelter" ignores its capacity to consider and support our higher aspirations of psychological comfort, intellectual stimulation and even delight in the built form.

The work of several authors in architecture and related disciplines provides the technical foundation for euthenics: Knudsen's research in acoustic comfort, Newman's design theories for security and safety, Arthur and Passini's work on "wayfinding," Gehl's guidelines for the design of interstitial spaces, Lynch's classification of spatial amenities, Appleton's philosophy of landscape aesthetics, Alexander's recognition of human living patterns, Hildebrand's embrace of prospect, refuge and novelty, and the need for perceivable order as professed by Arnheim. However, these key aspects are often neglected for lack of a place to consider them.

METHODOLOGY

The current sustainable analysis model uses a standard x-y analysis grid, representing the environmental factors on one axis and economic ones on the other. By expanding the grid to include the z axis of human factors, we form a place to discover the patterns within. In what can be called the "eCUBE," the ecological axis, the economic axis, and the euthenic axis combine to map a three-dimensional framework to analyze the comparative sustainability of competing strategies. The economic scale tracks the relative efficiencies (savings vs. costs) or reuse value for each strategy. The ecological scale traces the relative benefits to the natural environment such as clean air and water, reduced waste and pollution, and the conservation of natural resources. The euthenic scale tracks the relative benefits to human participants of the built environment such as physical health, psychological comfort, and intellectual stimulation. The methodology consists of three steps for each of these scales.



Figure 2 One-dimensional scales of parallel strategies/technologies.

Step One

Beginning in one dimension, the parallel strategies for the design of a particular building element are prioritized linearly along each axis according to adopted criteria. For example, the need for sufficient light in a room may be satisfied through the use of natural daylight, artificial light or a combination of both. Each of these strategies can be achieved by a multitude of technologies: natural ones such as vision glazing, light shelves, skylights, light tubes, and/or artificial ones such as task lighting, overhead lights, indirect lighting, etc. The point of this step is simply to place the strategies available to a design in the proper order along the economic, ecological and euthenic scales, in turn. This order is specific to the project and highly subjective; as it should be in this early phase. To facilitate the process, a prioritizing grid (Bolles, 1989) is used derive and record the placement of the parallel strategies.

Step Two

Single dimensional scales are combined to form a two dimensional grid where the importance of a design strategy on one axis is juxtaposed with its importance on another. This relationship is projected onto a standard two–dimensional graph that permits a comparison of the trade-offs for select strategies. For example, efficient fluorescent lighting fixtures can be compared to harnessing natural daylight, with its obvious ecological and potential economic gains.

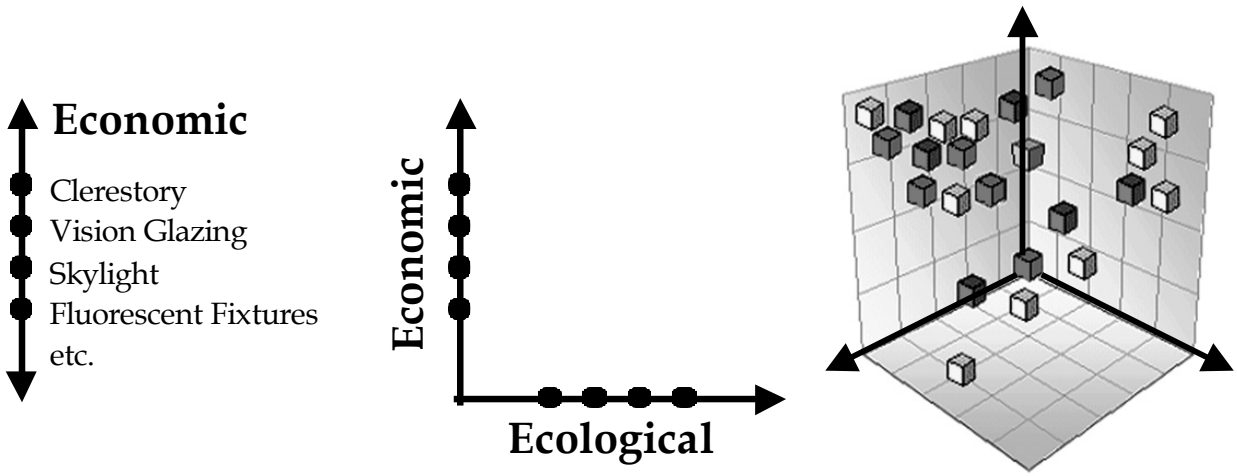

Figure 3 Progression from one to two and from two to three-dimensional scales.

Step Three
The graph is then extruded along the third axis of the euthenic scale. The two-dimensional spatial relationships are maintained and further enriched by the depth of the third. For example, the advantages of strategies encompassing natural daylight are pronounced: full-spectrum light quality, connection to the outdoors, and thermal gains. In this space, all parallel design strategies are presented for comparison. Those strategies closer to the optimal corner of the cube are selected.

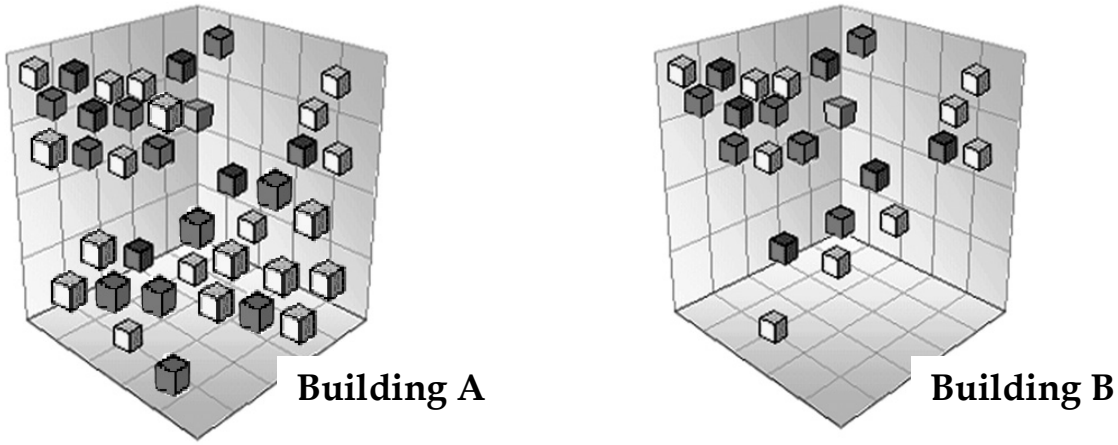

Figure 4 Comparison of the three-dimensional maps of two buildings.

Each selected strategy is then compiled into a new cube that represents all components for a comprehensive building design. By plotting several strategies simultaneously, this grouping of superior alternatives guides the design of that building and allows its comparison to other buildings. After building completion, the *overall* performance of the building is subjectively evaluated and credit is awarded to each component strategy of a successful design. The relative strength of each strategy is revised and compiled for future use. The prioritized strategies and evaluation criteria for each axis remain dynamic as new inputs are received and the three-dimensional grid expands to accommodate them. In this way, general patterns of superior design strategies are identified and used to guide the design of other buildings. For example, a consistently successful daylighting strategy increases its strength within the whole matrix. This information may also be extrapolated to the design of city blocks, neighborhoods and cities.

IMPLICATIONS
Why include these aspects in the design of buildings? Because it pays; economically, ecologically and socially. The increase in productivity is only a relatively minor benefit when compared with the psychological wellbeing that reaching the heights of Maslow's pyramid can deliver. One advantage of this conceptual model is its comprehensive scope of all the issues related to sustainability and building design. The process of extraction (whether of resources or concepts) without due consideration of the consequences is not possible within a connected, integrated structure. Sustainable architecture is considerate architecture. Therefore, our conceptual model should avoid the pitfalls of mono-dimensional abstraction where a numerical *index* of sustainability is severed from its context.

Another advantage is that the system and criteria are dynamic. Novel strategies and technologies are accommodated along an elastic scale that, surprisingly, exhibits coherence

under change. Priorities may easily shift and holes in the grid identify opportunities for the development of new strategies. Even historical examples of successful buildings may be mapped and added to the framework to guide future design. This system also permits customization by setting performance thresholds along each of the three axes to fit a particular program or region.

The goal of euthenics, and this methodology in general, is to identify a *process* to locate and use *patterns* in the design of *structures* that improve the built environment for the purpose of increasing our human potential. In systems thinking the patterns of relationships are more indicative of performance than the entities that are interrelated. This shift from function (structure) to organization (pattern) is a prerequisite to the development of sustainability.

> *Until we have an understanding of these complicated, changing interactions, our attempts to balance extraction of ecosystem resources against sustainability will remain at best naïve, at worst disastrous.* (Holland, 1995, p.4)

The progress of sustainability is dependent on our ability to effectively consider these complexities. The proposed framework greatly facilitates decision-making by harnessing our human endowment for judging spatial relationships while maintaining the reality behind the abstraction. The model also attempts to *quantify* the subjective aspect of intuition in the design process for the economic, ecological and euthenic benefit of our greater environment.

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Decentral water systems in dense cities - The purifying water garden as a technical, symbolic and environmental means to redevelop and restructure existing city-districts.

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INTRODUCTION

High densities of built-up city-districts are the cause of diminishing contact between men and nature. That is how these days the natural water cycle has become a completely invisible phenomenon that has been replaced by a system of thousands of kilometres of technical infrastructure deep down under the ground. The mystery of the water cycle is far away from people's minds and very few people are giving it any thought at all.
In the past people realised the importance of water; they worshipped the gods of the water and water wells were holy places, where people came to drink or to bathe. But as water became easier to obtain people started to become more careless about it. However, because of the pollution problems of our days the awareness that this cannot go on any longer is growing. The question is: 'In what way can we make the public understand the consequences of their excessive use of the earth?' The well-known proverb: 'Change the world, starting with yourself', is the motto for this project.
This paper means to state that the consumer himself needs to take full responsibility again for his actions as far as the water cycle is concerned. But what if when nature has been evicted from the environment? There is hardly a citizen to be found who knows about natural water-purification. To make the inhabitants of a dense city realise the impact of their actions and the consequences on the cycles; nature has to be brought back to the city.
Decentralisation and visibility of the water cycles can be obtained by introducing natural water-purification gardens in the city-districts. The implementation of this nature in dense cities offers the inhabitants possibilities for use on an aesthetic, educational-social and environmental-technical level. This will be illustrated by a case study for a decentral water system on the 'Noordereiland' in Rotterdam, the Netherlands.

THEORY

Mankind's need for water, energy and material-matter has been drastically increased in the last century due to the rising average level of prosperity and world population. This means that an

extending 'technical apparatus' is necessary to provide the increasing demands. As a consequence there is more need to intervene in the existing natural cycles, resulting in more environmental problems. Pollution of the water, floods and shortage of drinking water are only some of the actual problems in the area of water management in cities. For the control of the water economy in the cities, usually one only thinks in technical resolutions subordinating the aesthetic composition (H. Pötz, P. Bleuzé. 1998). But by only 'solving' the symptoms without tackling the cause of the problems most of the problems will be postponed towards next generations or other scale-levels. Therefore to prevent cumulative effects, good solutions have to be found at the source of the cycles. Innovative technical innovation can indeed contribute in these matters, but that alone will not be enough. This problem needs another relation between human and natural cycles.
To solve the actual problems the cause shall have to be removed. This means that the consumer must be made aware of his wasting behaviour in regard to water and water cycles in our modern society. This can only happen if we look for solutions that contribute to a liveable city and a lasting, permanent use of water in which the consumer is the focus point. This can be achieved through an integral approach, by which the problem is looked at from different angles. An integral plan contains the following three aspects (Fig.1):

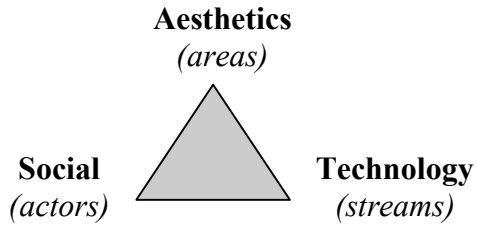

Figure 1 EnvironMENTAL Design-strategy (Tjallingii, 1996)

DECENTRAL WATER SYSTEM
A decentral natural water system is an example of an integrated solution. It might enhance the quality of life and the responsibility and the awareness of the consumer. The above-mentioned approaches are explained as follows:

Technology
From an environmental-technical point of view is closing-in the water cycles on a city-district-level a long-lasting development, because this diminishes the energy-capacity for the transportation and purification of the water. The use of water-purification in a natural way with aquatic plants in concepts like the 'Living Machine' (Living Machines, inc. 2000), and not with the modern technical and chemical procedures, can make the environment more sustainable. The effects are reduced to nearby the consumer. Problems are easier to discover and changing the consumer's behaviour can easier be established.

Aesthetics
The aesthetic quality of our environment is enlarged by decentral purifying water systems. The presence of water and the natural systems in our buildings, neighbourhoods and cities offer starting points for landscape design, for instance in the shape of waterworks, like fountains and ornamental basins and green plantations. Nature also has a positive effect on the climate and the quality of the air in the city.

Social
Decentral water systems also have a social aspect. By closing the circulation within the districts themselves and making it visible, it works as an information-carrier of nature. It not only makes the consumer more aware of his own behaviour, but it also stimulates the user to take more responsibility in regard to the circular course of the water.

CASE STUDY
To make this theory tangible a decentral water system is designed for the 'Noordereiland' in Rotterdam (the Netherlands). The Harbour City of Rotterdam (600 000 inhabitants) is situated in the west of the Netherlands near the coastline. The river Maas runs through the city and separates the old centre-area on the north bank from the new centre on the south bank. Both areas have their own water (drainage) system.
The 'Noordereiland' is a pre-war housing district (3 600 inhabitants), situated on an island in the River Maas and forms an important link between the centres on both side of the river. The water (drainage) system of the island has a death-end connection with the northerly area (Fig. 2a).
The island district has an above average housing-density (94 houses /10 000 m3) on 210 000 m3.

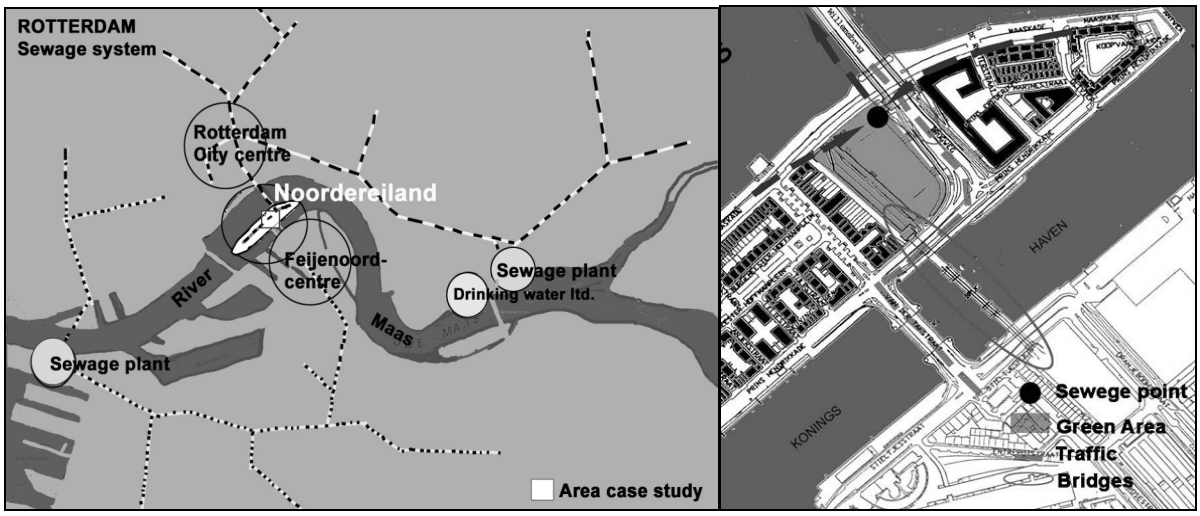

Figure 2a Map of Rotterdam (incl. sewage system) 2b Map of the area

The chosen area of application is a central area situated between the bridges. The area has been wasteland from the construction of the new railway tunnel in 1996 on (Fig. 2b).
The system of this district will be viewed in the light of the three formerly stated points of view.

Social aspect
The social aspect has been important when choosing the Noordereiland as location. Decentral systems in an existing city-structure demand for the inhabitants to adjust their lifestyle and to start to cooperate to achieve a fertile ecosystem. This is only possible when there is a clear encircled area and a close community. The 'Noordereiland' as an island is perfect for this purpose. Although inhabitants are usually more intensively involved when using smaller decentral systems (between 20-200 houses) there is chosen to develop in this case study a system that serves the island as a whole. The central position and the visibility of one decentral system

can still increase the awareness of users collectivises, which in turn will prompt to responsible behaviour.
The 'Noordereiland' has always been an enclave in Rotterdam and it used to have its own culture of rich businesspeople and seamen. The past decades the district developed into a backward-area, with high crime-rates. Only in the last few years, due to the redevelopment of the old harbour-districts around, the area has started to flourish again slowly and attracting young people. The community has become closer evermore and it has its own community centre. The ecological preservation of the island and the institution of a function above district-level at the chosen location can give extra stimulus to support these tendencies.

Technical aspect
The closing-off of the water cycle is the environmental-technical way to a permanent restructuring of the Noordereiland. It's necessary because the water cycle of the Noordereiland has an extensive reach at the moment and is known to be a heavy burden on the environment.
The *OUT-put* site of the current water system has some main problems.

- The sewage-water is transported from wastewater purification plant and the 'Noordereiland' over 10-km underground. This costs much energy and material.
- Leakage in the sewerage pollutes the groundwater and the surface water. The old concrete pipelines on the island have started to leak in many places over the years.
- Pollution of the surface-water occurs through sewerage pouring over by heavy rainfall. According to present Dutch law 10 pour-over times a year are permitted for the outer dike-areas such as the Noordereiland. Calculations on the capacity of the sewerage-system of the island and its pumping outlet-system have shown that this already occurs at a rainfall of more than 16-mm per day. This happens far more often than 10 times a year. The main cause lies in the fact that over 83 % of the island-surface have been connected with the sewer.

At the *IN-PUT* site the transportation of the water takes a lot of energy as well. The water for the water production plant even comes from water-win-areas at a 50-km distance.

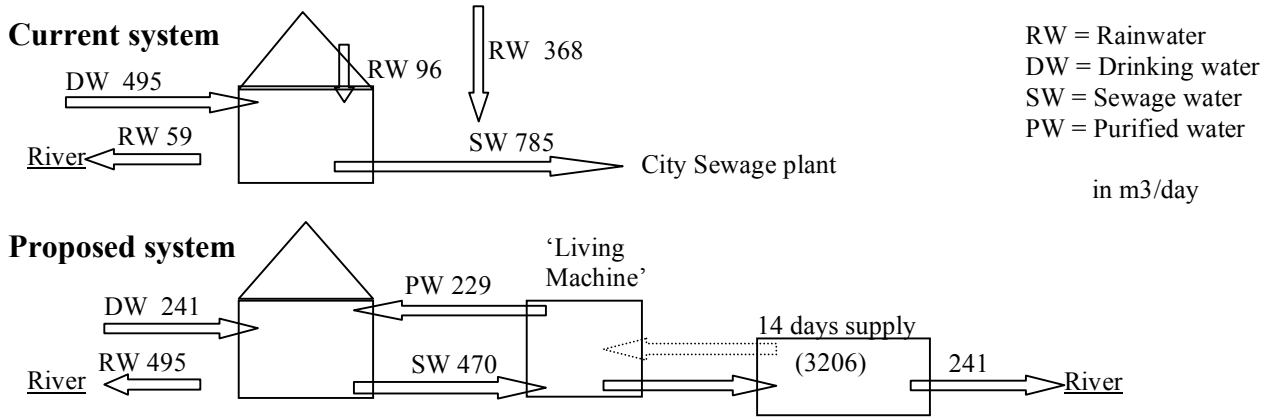

Figure 3 Sewage scheme with current water-use and proposed decentral sewage system for district Noordereiland in m3/day

A new decentral water system can solve these problems and make the island more sustainable. The solution is to be found in recovery of the sewage system and in the separation of the water in different grades of pollution at the source and after that treated separately.
Adjustments at the *OUT-PUT* site:

The drainage system will be disconnected from the northerly sewerage network of the city and partly recovered (Fig. 2a).

- All the relatively clean rainwater that causes overflowing gets disconnected immediately from the sewer. From the houses the rainwater gets drained away from the area into the river Maas through visible waterworks and water-playworks.
- The 'polluted' water from the houses gets caught into two separated pipelines for respectively domestic wastewater and for toilet flushing. These two networks will transported to the 'Living Machine[1]' at the location between the two bridges. In this 'Living Machine' the water gets channelled through the glasshouses in a number of smaller water streams. It will be purified in six steps by different plant- and biological- culture-systems, like algae or bacteria.
- The 'purified water' in de 'Living Machine' will be partly channelled back to the district as 'domestic water' and partly stored in an underground water reservoir in the centre of the building. The water that is superfluous will be drained into the river Maas (Fig. 3).

Adjustments at the *IN-PUT* side:

- It proved to be impossible to disconnect the drinking-water-supply but the suggested decentral system restricts itself at the supply-side on diminishing the consumption of water for 30%[2] through water-saving technical means and by 'mental' means (like water-meters) that stimulate the awareness.
- Besides that, the use of drinking water can also be restricted by a second pipeline-system with 'purified water' form de 'Living Machine' for washing machines and toilet use. By 're-use' of this wastewater the recycling of the water is completed (Fig. 3).

Esthetical aspect

To keep a densely populated area like the city of Rotterdam or the Noordereiland liveable, it is important to have sufficient of nature around. Rotterdam however has been expanding rapidly in a few years time and the typical Dutch broad landscape can only be found far outside the city. The present municipal policy in Rotterdam is to sacrifice the last green-places inside the city and revaluate some others to intensify the use. The location of this case study was originally intended for offices building. This project tries to give an alternative with preserves the present green character of the location because of the high density of the built-up area around it. As well of the fact that the surface of the island exists at the moment for 94% of pavement (buildings and roads). The location between the bridges is the last really non-'paved' area. It can become a green-area for social contacts and for rest in the noisy city. Not only for the islanders, but also for the people in the surrounding districts. By using the location in a plural way and with plural ground-use it can preserve the potentials at the different scale-levels.

THE SITE

To utilise this specific location to full extend two extra municipal functions added to it. Making plural use of the ground at the development of a decentral system in a dense city-structure offers good prospects for making the system profitable. Through the integration of the 'Living Machine' at the one side in a public park at the talus-level of the bridges and at the other side an

[1] In view of the local situation a natural system in glasshouses is chosen, because of lack of space on the island. This relatively compact 'Living Machine' can handle the water-purification for the 1900 households in this dense city district. The glasshouses of this system guarantee the continuity of the system and protection against atmospheric pollution and vandalism.

[2] This equalises the estimated water-use-increase of 25% in next years.

information-centre combined with a swimming centre at the level of the riverside-wall. The 'Living Machine' has been separated in 6 smaller glass-houses that each embodies a step in the purifying process (Fig. 5 plan).

The water tanks in the glasshouses are made at the riverside-quay and form the outside walls of the swimming-centre. The pool visitor can enter the glasshouses when walking or swimming and imagines to be in an oasis of water and green. Enjoying the natural beauty one can relax completely (Fig. 5 section). The glasshouses of the 'Living Machine' reach out through the roof of the swimming centre and are situated as spatial objects in the park as in Parc Citroen in Paris (Lavalou, A, 1992). Visitor can walk around these elements and in this way they can follow the purifying process from above. For the interested people there is the possibility to come down to the information-centre where an exposition about the whole water-treatment and some glass-houses are to be visited. For the inhabitants of the island up-to-date information about the state of the environmental aspects on the island are shown, like the consumption rate of the water. It also is a meeting-place for announcements for the neighbourhood and a place to collect garbage in 14 different fragments. A small bio-gas-installation turns the green waste into energy that will be used for heating the swimming pools.

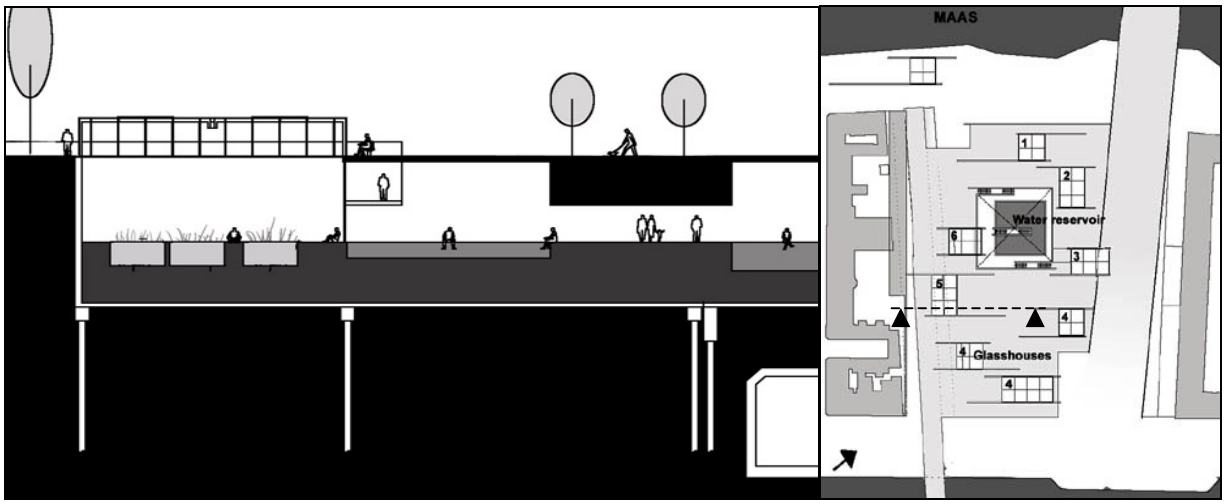

Figure 5 Section and plan of the park (with glasshouses) and swimming centre

CONCLUSION

Decentral water systems redevelop and restructure dense cities-districts more sustainable by integrating environmental-technical, esthetical and social aspects on a low scale level. Besides that, the liveability, the sustainability and responsibility will be enlarged on all scale levels; for the consumer, the dense city, as well as the human-consumers-chains.

Natural wastewater purification systems integrated in urban areas or buildings not only help to revalue the public space by the implantation of nature but it also increases the users awareness and makes them more conscious in their acting. When decentral water system are integrated in the public space by plural ground-use, they can by economical feasible even in dense cities.

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Energetic and Environmental Profile of a Building Material: a Case Study on Sicilian Tuff

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1. INTRODUCTION

In the last years the new environmental issues have deeply changed planning practices in the building sector and the way of selecting building materials. Energy management must balance justifiable energy demand with appropriate energy supply, coupling the energy conservation, and energy efficiency with the use of primary renewable energy resources. The requirement of environmental sustainability has to be referred to the life cycle of each building component, as regards to the following steps: (1) raw materials extraction; (2) production; (3) transport; (4) end-use; (5) reuse and/or recycling; (6) final disposal (Ryding, 1999).

Despite the Life Cycle Assessment of buildings involves a high degree of complexity, it is necessary to calculate the energetic and environmental performance of building materials, in order to evaluate the ecological effects and to assume the environmental items as suitable supports for multi-criteria decision making approaches (Beccali *et al.*, 1997a).

In this paper the eco-profile of tuff is presented, referring to a sicilian firm. The Authors assess energetic and environmental performance of tuff and its production cycle. Extraction of resource, consumption of energy and environmental releases are estimated, carrying out energy and mass balance in the inventory step.

The aim of this study is to provide a suitable tool in aid of decision-making, in the comparison among alternative materials and/or for the technological improvement of the production system.

2. METHODOLOGY

2.1 Aim of Study

The eco-balance of tuff is carried out, according to the following steps: (1) Goal Definition; (2) Detention of functional unit and system boundary; (3) Inventory Analysis; (4) Sensitivity

Analysis; (5) Classification. In particular, the eco-profile of tuff block is performed (size 16x45x27 cm and weight 26,78 kg).

2.2 Goal Definition

The aim of the analysis is to assess the energetic and environmental performances of tuff, identifying the energy consumptions and suitable technogical improvements in the production process. The life cycle assessment is limited to the extraction and production of tuff and any comparison among replaceable materials is not carried out.

2.3 Functional Unit and System boundary

The selected functional unit[1] is the number of tuff blocks in a square metric of wall and all the outcomes of analysis are referred to it. In particular, resources inputs, such as the consumption of electric power, diesel oil and lubricants, and outputs, as solid wastes, sands, and air emissions, are estimated for the inquired firm, but no consideration is made about the impacts induced on the local context.

From a methodological point of view, analysis is limited to the extended technological level. In fact, the correlated processes are also included to make available the economic inputs, which are required for the main process. Resources consumption and environmental releases are estimated for fuels, power energy, and raw materials, which are required by the main process. The transport of materials from quarry to manufacturing place, the extraction process and transport of fuels, and production cycle of machineries haven't been considered.

Figure 1 shows the flow sheet of the tuff production process that takes place in the examined firm, in order to have an overview of the overall production cycle and of the other referred activities. In this figure the inside transport is included as relevant source of resource consumption and air emission.

2.3. Quality and origin of data

Data have been collected by in-field enquiry and sector bibliographical references. In detail, the analysis is essentially addressed on calculating the following items:

- Environmental and economic inputs/outputs in the tuff life cycle (Figure 2): (1) consumption of electric power by cutter-machines; (2) consumption of lubricant[2] by the different mechanical plants, such as cutter-machines, lorries, and shovels; (3) consumption of diesel oil by transport and placing of tuff blocks inside the firm.
- Variation in the specific values of energy consumption between the inquired firm and the in the regional context.
- Comparison among the different eco-profiles.

The eco-inventory of 1 MJ of electric power is derived, referring to the three following databases:

- The UCPTE 90 model (AA.VV., 1994).
- The I-LCA model (ANPA, 2000)
- The global UCPTE 90/I-LCA database model (ANPA, 2000).

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[1] The functional unit represents the reference, by means of which the collected data are normalized and to which the analysis outcomes are referred. Its definition has to be consistent with the function of the examined system and it can be seen as an index of the system performance.

[2] The data on air emissions are available, referring to extraction and distribution processes to users. Instead, the lubricants use by mechanical means are lacking.

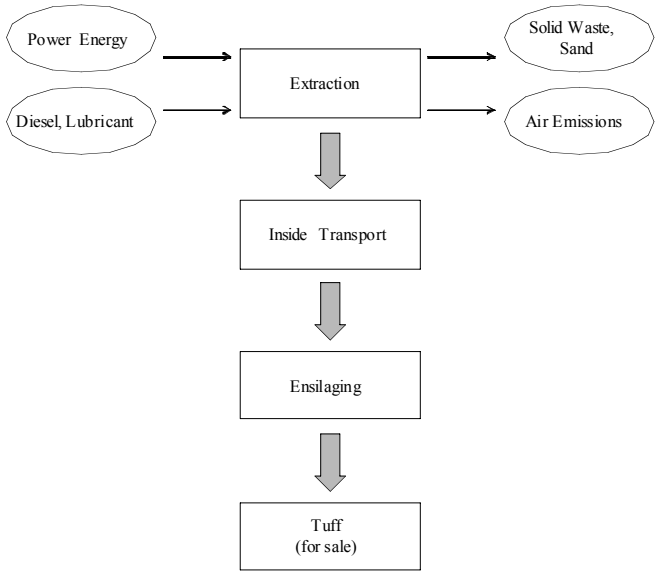

Figure 1 Flow sheet of the tuff production process

2.4 Inventory Analysis

After the data collection, the extent to which the process occurs, or the process tree, is defined (Figure 2).

The Life Cycle Assessment of a building material should include each transformation step from raw materials extraction to disposal. It is possible to analyze all the energetic flows and environmental impacts step by step, until the manufacture of end-product that is "from cradle to gate". The further stages that occur during the end-use and disposal are covered by a high level of uncertainty and could not be object of a detailed analysis.

In the inventory analysis the required energy and material resources, and the environmental releases are estimated. In Figure 3 the mass balance is shown, referring to the extraction step of the functional unit, while in Table 1 energy inputs are reported.

Resources consumption and emissions are calculated and the energetic and environmental profile is obtained for tuff, referring to each used database. The relevant items to the environmental impact have been classified according to the following criteria (Heijungs, 1996), as shown in Table 3:

- Abiotic resources depletion (1/reserve)
- Consumption of primary energy (GER)
- Global Warming (GWP_{100})
- Photochemical smog (POCP)
- Nitrification (NP)
- Acidification (AP)
- Human Toxicity (HCA, HCW, HCS)
- Eco-toxicity (ECA, ECT)
- Odour (1/OTV).

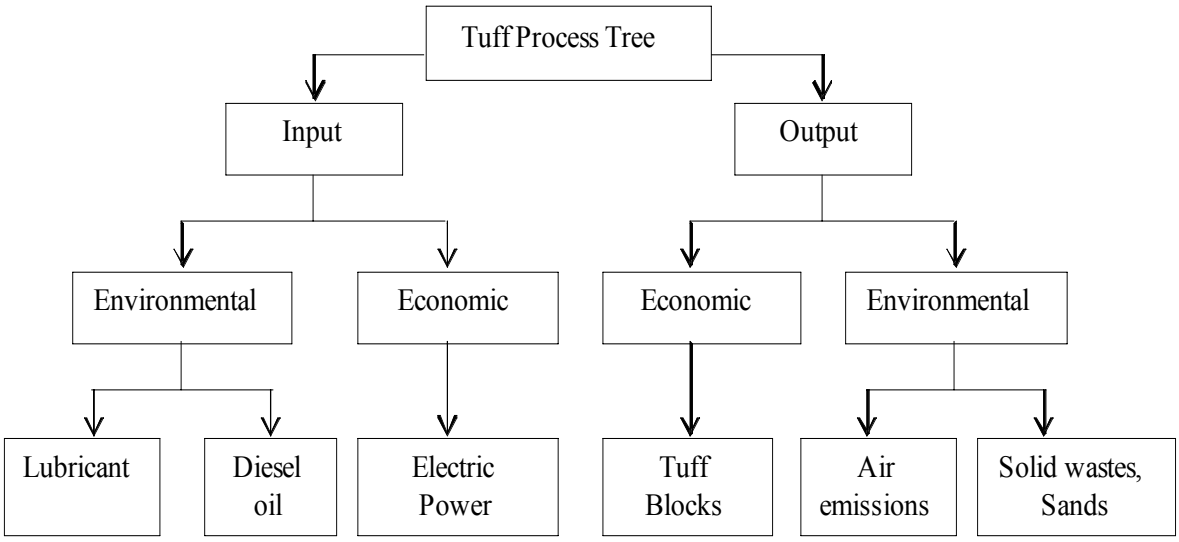

Figure 2 Process tree of the tuff blocks production.

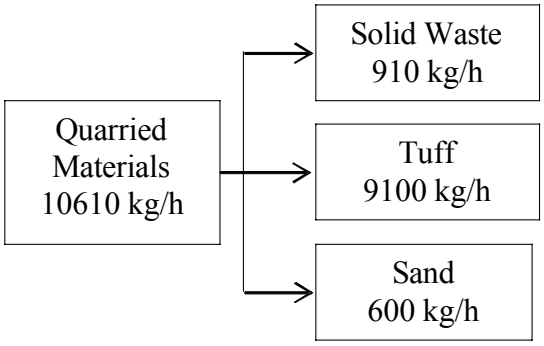

Figure 3 Mass Balance in the extraction process

Table 1 Energy consumption per functional unit.

Power Energy [MJ]	Diesel [MJ]
2.4	4

The matrix method is used to calculate the inventory table (Table 2) (Beccali *et al.*, 1997b).

Table 2 Ecobalance of tuff per functional unit.

	UCPTE 90	I-LCA	UCPTE90/I-LCA
Resources (kg)	4.15E+03	2.40E+02	1.60E+02
Air emissions (kg)	2.23E+03	1.52E+02	1.52E+02
Water releases (kg)	7.38E+01	5.24E+01	6.27E+01
Solid wastes (kg)	4.38E-03	5.57E-03	4.80E-03

Table 3 Calculation of the classification factors per functional unit.

Classification factors	UCPTE 90	I-LCA	UCPTE90/I-LCA
(1/Reserve) [yr^{-1}]	2.57E-03	7.89E-04	4.06E-04
GER	1.50E-01	3.19E-01	2.03E-01
GWP_{100} [kg]	1.99E+01	4.45E+01	3.97E+01
POCP	1.96E-04	4.52E-04	3.71E-04
NP	4.80E-03	2.63E-04	1.77E-04
AP	1.90E-01	4.80E-02	2.50E-02
Human Toxicity	4.94E-01	5.05E-02	4.05E-02
ECA	5.08E-05	5.26E-06	6.70E-06
ECT	1.36E-04	3.46E-05	4.08E-05
1/OTV	1.20E-05	8.67E-05	8.57E-05

2.5 Sensitivity Analysis

Sensitivity analysis is carried out in order to assess the tuff eco-profile variation, modifying the primary data. It depends on the linearity of the aggregation model used for the inventory matrix, so that the effect of each factor can be considered independent from the others.

In general, sensitivity analysis is performed when specific mean data of energy consumption are available at national scale. In this study, for the lacking of national databases of the needed data about the above process, the representativity of the analyzed firm is evaluated in the regional context. Available data are collected, referring to quarrying process at a regional scale. That gives the possibility to carry out the sensitivity analysis in order to quantify the variation induced on tuff eco-profile, varying original data. Referring to the regional mean specific values for the consumption of electric power, diesel oil, and lubricant, the Authors estimate the numerical variations on the energetic and environmental balance of tuff, induced by the mean regional data, compared to data of the examined firm. Table 4 shows the comparison among the inventory matrices, which are calculated for the three data sources. Outcomes show minimum differences among the two eco-profiles.

4. CONCLUSIONS

In the last years energetic efficiency is becoming one of the most relevant factors for environmental profile of buildings materials, together to raw materials and energy consumption, and waste generation. The need of environmentally oriented systems in the production of building materials has to be considered more relevant, referring to the quantitative of building sector at national level.

In this paper the ecobalance of tuff has been presented, depending on the widespread use of such material in buildings. The Life Cycle Assessment has been carried out by means of matrix method, in order to take into account the different processes correlated to the main one that influence the energetic and environmental performance of tuff.

Sensitivity analysis has made possible to estimate the numerical variation induced on tuff ecobalance, changing the primary data. Besides, an environmental improvement of tuff

Table 4 Comparison between the matrix inventory of tuff in the examined firm and the regional one

		Examined Firm	Regional Scale	Numerical Variation
UCPTE 90	Resources (kg)	6.42E+03	5.17E+03	1.25E+03
	Air emissions (kg)	6.42E+02	5.15E+02	1.27E+02
	Water releases (kg)	1.42E+01	1.11E+01	3.10E+00
I-LCA	Resources (kg)	2.32E+02	2.40E+02	8.00E+00
	Air emissions (kg)	8.84E+01	9.08E+01	2.40E+00
	Water releases (kg)	1.78E+01	1.79E+01	1.00E-01
UCPTE90/I-LCA	Resources (kg)	4.37E+02	4.52E+02	1.50E+01
	Air emissions (kg)	1.39E+01	1.42E+01	3.00E-01
	Water releases (kg)	1.81E+01	1.82E+01	1.00E-01

ecoprofile could be reached, by means of the substitution of the diesel oil with methan. In fact, such fuel could determine the reduction of the resources consumption and of the environmental releases.

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Urban Occupation Patterns and Microclimates an index for decision-making

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1. INTRODUCTION

The subject of this paper is urban microclimate in cities of the Brazilian Continental Tropical Region, taking as a case study the city of Cuiabá, capital of Mato Grosso State, in the center of South America. After a slow and unstable growth, the city is starting a new stage of its history, planning the rehabilitation of its downtown area and the occupation of new neighborhoods, aiming urban sustainability.

After establishing a statistical correlation between air temperature and some of the variables that physically define the occupation pattern of an urban area, this work suggests an index for decision-making process relating *built density*, *trees* and *water* in urban environments. These variables can be controlled by municipal regulations and planning, with the aim of guiding the procedures to improve harsh urban climates.

2. THE LOCAL CLIMATE

The climate is hot, with an almost daily frequency of high temperatures; in the warmer months (September or October), the maximum temperature can easily reach 40ºC. Another important characteristic is the definite seasonal rhythm of precipitation, with a distinct dry season in the winter period. However, in the wet season, there are strong rains, alternating with transition periods of intense heat; in this period flooding is common along the rivers and streams which cross the city. The average altitude of the urban area is lower than 200m, and it is surrounded by large plateaus of more than 800m above sea level, which gives the area geographical depression characteristics. Due to this fact, ventilation is very weak. The native vegetation cover is made up of savannah and riparian vegetation.

3. THE URBAN OCCUPATION

In Cuiabá, the first area to be set up is occupied since the Portuguese colonial period in the 18th Century. Until the beginning of the 20th Century, Cuiabá resembled Portugal settlements, as do other Brazilian cities. Narrow and winding streets along a stream with terraced houses formed the old centre. By following ancient urbanistic traditions of Portugal, our villages and cities had uniform streets, with residences built on the street alignment and sidewalls on the limits of the land. They showed a formal concern, aiming to guarantee a Portuguese appearance to our cities. In the old core, except for a small park (Morro da Luz), there are trees only in some green squares and in a few remaining backyards. Despite the streets do not have significant arborisation, all the ancient back yards are covered by exuberant vegetation.

Only in the middle of the 20th century the urban pattern became more defined. The contemporaneous aspect of the city has started with the new Brazilian capital construction (Brasília), which came to reinforce the cities growing in the middle west of Brazil. Then, southern migratory fluxes started to press the city, which was not prepared to absorb them. The new city-growing axes have being occupied especially after the 80's, where the new commercial buildings are concentrated. Despite the proximity to the old core, the urban pattern is completely different from the surrounding older neighborhoods, with tall buildings along wide and paved avenues. With a few exceptions, vegetation is restricted to young trees recently planted along the streets. The avenues are wide, totally different from the older neighborhoods, where shading is a natural result of the building pattern.

3.1 The Master Plan

The city Master Plan (CUIABÁ, 1992) has being elaborated in steps by the Urban Development and Research Institute, since 1992. The Land Use Regulations of 1997 proposed, among other directives, to raise the population density in order to reduce infrastructure costs; nowadays the average population density is 25 inhabitants/ha. This regulation has proposed alterations on account of infrastructure availability, raising the floor area ratio of 4 (maximum allowed before) to 6, in certain areas.

With this regulation, the basic criterion of different land occupation standards is the availability of urban infrastructure. Streets were classified in the following standards: not habitable, minimum, medium, high and maximum infrastructures. From the medium standard up, streets must have pavement and consolidated public arborisation, i.e., trees or palms adapted to the environment, minimum 2m high. The regulation also considers as an adequate lot use the existence and maintenance of adult trees or palms, registered by the municipal environmental agency, a minimum proportion of one tree per each 180m^2 of the lot. For each registered adult tree or palm the owner will have a 1% discount on property taxes. Transfer of building rights also has been adopted by purchase, exchange or social work. Incomes from these acquisitions would be credited to the Municipal Urban Development Fund.

4. CORRELATION BETWEEN AIR TEMPERATURE AND URBAN OCCUPATION VARIABLES

By establishing the correlation degree (r) between the air temperature and each urban occupation planning variable (Figure 1) in seven studied neighbourhoods (Horto, P. Ramos, Araés, M. Luz, Av. CPA, UFMT and INMET) in the city of Cuiabá, it was possible to discover the relation of each variable with air temperature and their periods of major influence. Grouping data at 8 a.m., 2 p.m. and 8 p.m., 216 linear correlation tests were performed and linear regression equations between the air temperature and each urban occupation variable were established (DUARTE and SERRA, 2001).

Results show that correlation is positive, from 0.57 to 0.81 for the *percentage of the land covered by structures*, and from 0.63 to 0.87 for *floor area ratio (FAR)*, in the early morning and at night, reflecting the greater influence of built-up density at night, in agreement with the existing theory. At 2 p.m. the major heat transfer through convection explains the weak correlation between urban occupation and the air temperature (from 0.22 to 0.53 for the percentage of the land covered by structures and from 0.32 to 0.63 for floor area ratio). On the other hand, quantifying *tree canopies projection* and *water surfaces*, the correlation was negative, around – 0.4 and – 0.37, respectively, in all periods when related to the air temperature.

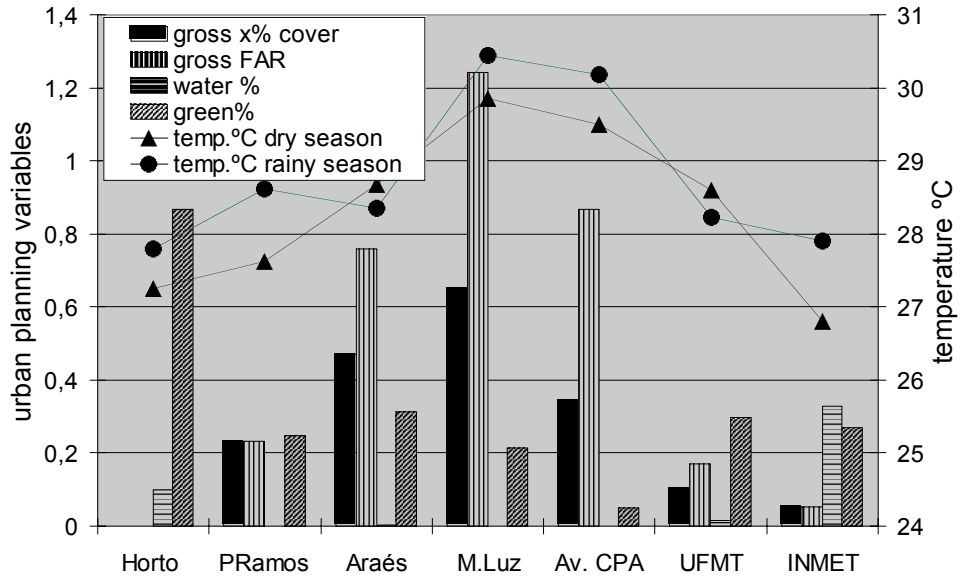

Figure 1 Gross *percentage of the land covered by structures, floor area ratio (FAR), water surfaces* and *trees* versus mean temperature in both dry and humid seasons.

5. AN INDEX FOR DECISION MAKING PROCESS

After the correlation mentioned before, and index for decision-making process is proposed. These variables can be controlled by municipal regulations and planning, with the aim of guiding the procedures to improve harsh urban climates. Indeed, aspects such as water surfaces and forestation could be the result of municipal decision makers. Generally speaking, there are two types of city builders: the public and the private. In average, private builders account for more than 60% of the area of the city in Brazil, and public works account for the other 40%. The control over private builders is made through urban regulation. As for the public builders, control can be made through the city council, citizens' councils and public opinion. In any case, the control of the decision making process is exercised through political means, and is supported by plans and projects.

Instead of measuring green areas as a function of population, as usual in Brazil, it would be more useful to determine it as a function of *built density* for each neighborhood. According to GIVONI (1998), the effects of plants on the climate in the built-up areas depend on the *fraction of green areas*, public as well as private, relative to the whole *built-up* urban area. Therefore, from the air quality and thermal comfort points of view, the index *green area per inhabitant* for the whole city is not useful enough. Even if it is high, the trees can be concentrated in a few points, with little or none benefits for people.

The proposed index is more adequate to urban planning and, after checked in other cities, it can gives recommendations to the proportion between vegetation and water surfaces to ameliorate urban climate and human thermal comfort in urban areas. Following these procedures, it is possible to know if green areas are distributed or concentrated in a few spots in the city, and the proportion related to the built environment. Several authors recommend the vegetation distribution in pockets spread all over the city instead of a single large park (OKE, 1973, GIVONI, 1991 and 1998, SPIRN, 1995, HONJO and TAKAKURA, 1990/91).

Urban oasis can be observed even in a large single tree, but microclimatic and air quality benefits are physically restricted to green and water surrounding areas and they are valid for only a few meters, even in large urban parks borders. Spreading the green in small parks makes more benefits to a large number of inhabitants. Also, this approach avoid that buildings dominate the urban landscape, but make them part of that.

Aiming to show the proportion between *built density* and *water and trees*, this index suggests the percentage of the land covered by structures multiplied by floor area ratio (the two main variables used by Brazilian land use codes) related to the total surfaces covered by water and/or shaded by trees. Following the former research (DUARTE and Serra, 2001), the first two variables have a positive correlation with air temperature, and the natural elements have a negative one. If the index only observes the percentage of the land covered by structures, it do not take into account the verticalization. Adding the floor area ratio, the total built area is included; on the other hand, with floor area ratio only, it could mean the occupation of the entire plot, creating a high horizontal density.

$$I = \frac{\text{percentage of the land covered by structures} \times \text{floor area ratio}}{\text{horizontal projection of trees canopies + water surfaces}}$$

Following this proposition, two approaches can be done: with *net values* for all variables, e.g., quantifying only the square blocks occupation, or with *gross values*, quantifying all the land occupied by streets, parks, etc, in the neighborhood. It is more interesting to work with *gross values*, once that for the climatic point of view it does not matter if the green areas are public or private. This makes difference at the time of the implementation of the recommended measures. In this first case study, the variables were quantified for seven homogenous urban pattern areas of 25ha. But, as the index can works with percentages, it is possible to use other dimensions. To determine the limits of the quantified area, what matters is the homogeneity of the urban occupation pattern. Therefore urban microclimate measures can be applied.

According to the proposed index, if the land covered by structures is 1 (100%), it represents the ratio between the total built area and the surface covered by water and/or shaded by trees. If the land covered by structures is lower than 1, more open spaces available and lower will be the index. Theoretically, the upper limit of the index is infinite. Even occupying 100% of the land, it is possible to build high-rise until the technology and the local codes permit.

This index is inversely proportional to the better thermal comfort conditions expected for that region, and can be used to compare different urban occupation patterns. Microclimate measurements were considered in this proposition because they determined the sign of the correlation (positive or negative) with air temperature and because they permit to compare the calculated index with local microclimates, as suggested in figure 2.

This index has to be checked in other case studies before any whole proposition, perhaps incorporating new variables. In this case, the idea is to work *exactly with the same variables used by Brazilian land use codes*, and that are easy to quantify, using aerial photographs and the Land Office, encouraging its application. There is a pressure from the more recent master plans in Brazil to increase population density, and urban microclimate is only one of the factors that determine if it is better or not. It depends of other facts, such as infrastructure availability. Theoretically, high density of low-rise buildings with uniform heights can cause a dramatic reduction in wind speed in the pedestrian level. Otherwise, high-rise buildings with

different heights are better than a flat roof appearance in the city, improving urban wind flow. Besides that, the distribution of pocket parks all over the city can helps to recover wind speed.

5.1 Examples of the index application to the city of Cuiabá

For the seven neighborhoods studied in Cuiabá, the three main urbanized ones are Araés, Morro da Luz and CPA; the other four are almost natural environments. Comparing urban occupation patterns with the mean temperature, in the main three urbanized cases, and in both dry and humid seasons, Araés has a predominant horizontal urban pattern with some high-rise buildings, but plenty of vegetation in the streets and back yards.

The CPA area presents the higher index. It has mainly high-rise buildings, with a lot of open spaces yet, but with very little vegetation. Because its open spaces, specific measures for this neighborhood should be developed, aiming to adjust the intended built density to green and water surfaces to ameliorate the local climate. This specific part of the city has a great potential for what GIVONI (1992) calls *urban cool island*; it is higher than the old downtown, with better ventilation and it is one of the main city-growing axes. Native vegetation was not preserved but, as it has a lot of empty lots, an extensive urban forest program can be put in practice.

GIVONI (1992) states that at a given density level, the best urban climate conditions exists in a hot-humid climate when that density is obtained with high narrow buildings ('towers'), placed as far apart from each other as is consistent with the given density. Such a configuration provides the best ventilation conditions for the given urban section as a whole, and especially for the occupants of the buildings. In Cuiabá, this area is the parameter for the new occupation areas, but the problem is the proportion between the built-up and the natural areas. A municipal regulation obliges minimum set-backs to avoid wind stagnation but it does not include green areas to compensate the floor area ratio of 6. And it is possible to develop a vertical occupation pattern, but with more natural elements too.

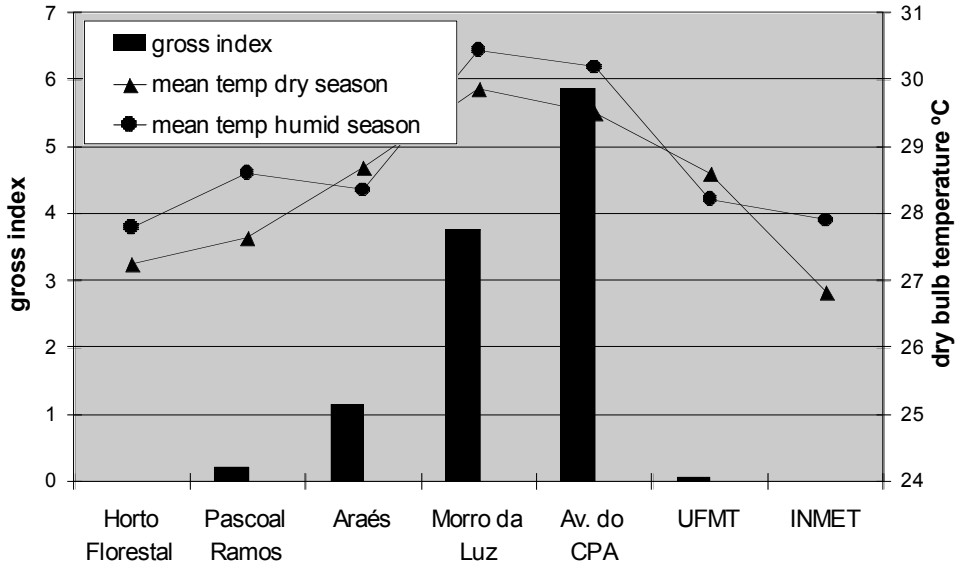

Figure 2 – Index for the seven studied neighborhoods in Cuiabá.

The function of this index for urban planning strategies is to compare the existent or intended built density with vegetation and water for each neighborhood. With the maximum values for

density, planners can determine an adequate proportion to green areas and water surfaces, considering costs and benefits. As a function of the expected microclimates, it is possible to establish better urban occupation patterns, always having in mind the local culture and traditions. In ancient neighborhoods, with potential for renovation, this index can be used to monitor built density, related to the existent vegetation in the remaining back yards. Another function is to establish a maximum index per plot. In such way, the responsibility for planting and maintenance should be shared by the population within municipal administration. Monitoring could be done by aerial or satellite photographs with high resolution.

6. FINAL CONSIDERATIONS

This proposition is not against the urban model. The solutions have to be found inside urban environments. The index compares different and viable urban occupation patterns - vertical, horizontal or mixed, with microclimatic conditions. It would be very interesting to increase private investor's participation in this process, especially in the city verticalization. In Brazil, the final built density which a neighborhood should reach is not taken into account to establish a green fraction. Every time urban regulation changes zoning or floor area ratio limits, it is not questioned a proportional increase for green areas.

Regarding Brazilian medium size cities (around 150.000 inhabitants) verticalization is irreversible. In spite of several recent researches, a lot of questions do not have answers yet. Parameters for built density and verticalization, for instance, are polemic among architects, urban planners, scientists and the real state market. The proposed index is not against higher densities too, as intended by the more recent master plans in Brazil. The plans aim to reduce infrastructure and services costs, displacements and energy consumption. The idea of the index is to balance built density and natural environment.

Observing the city from above, for the real state market, an unoccupied area is only an empty space to be built; for climatologists and urban planners it is an area that still can be used for the necessary interventions to improve urban quality of life.

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Environmental Impacts in Service Life Planning of Buildings – ISO/DIS 15686-6

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ABSTRACT

Within the existing ISO 15686 standard, a procedure for considering environmental impacts is under development. With the development of the draft international standard and in combination with ongoing standardization work in the field of whole life costing, the standard series in the field of service life planning for buildings and constructed assets develops towards a framework for a holistic project planning structure. The work item is to establish a procedure for the application of ISO 14040 "Life Cycle Assessment" within the context of ISO 15686 "Service Life Planning". Application of LCA results may come to place by using declarations, eco-profiles, or LCA databases. Due to the clarity of the scope, the emerging standard focuses on the application of LCA results in a building related planning process. As the working group developing the standard does not aim at stipulating the content of environmental sustainability, the procedure is expressed in flexible terms, relating environmental aspects of concern primarily to references, as identified in legislation / regulation, the demands and targets of the client, the building context and management routines existing in the involved organizations. The evolving standard reflects current developments of LCA in the building sector and identifies the interrelation between service life planning and LCA, not least in the advice to apply use-phase and end of life scenarios emerging from the service life planning procedure. Thereby, case specific rather than generic scenarios could be applied; hence leading to an improvement of the reliability of scenarios influencing the associated environmental impact of an assessed alternative.

The routine may be applied at any stage of the life cycle of a building. Further, the object of assessment may be an entire building or part of it. As the routine had to be flexible enough to allow for application in all these cases, the value of it has to be reviewed in this context. It gives however input to ongoing discussion on LCA development for application in the building sector; meanwhile it was ruled out to influence or complement standards in the ISO 14040 series. The ultimate goal of the standard is to enable decision takers to include environmental LCA information into their decision taking.

KEYWORDS

Life Cycle Assessment, Service Life Planning, LCA result application

INTRODUCTION

The standard procedure under development (ISO DIS 15686-6) is intended to establish a well specified and documented procedure that allows a designer to include environmental impacts into the portfolio of considerations that have to be gone trough when identifying materials or components to be included into an emerging building design. Meanwhile, the procedure is intended to be applicable in all stages of a building life cycle during which a project may occur. The standard procedure is not a stand-alone item, the design options that are subject of the assessment are to be identified prior to the assessment procedure, a description of pre-qualification or pre-selection is therefore, as well as the identification and establishment of assessment references, not part of the description.

In order to identify a procedure that allows the inclusion of environmental impact, the user will have to rely on additional methodologies and information sources in order to be able to perform an assessment. Expressly knowledge in the field of Life Cycle Assessment, the generation of usage phase scenarios and end of life scenarios, as well as knowledge about the limitations of comparability of data is crucial.

PERFORMANCE REFERENCES

Apparently, successful addressing of environmental impacts within the project planning requires that targets for environmental performance are equally well established as targets in other fields, such as economic or technical performance, see for instance (Trinius 2002) in these proceedings. Performance references can originate from sources that are, seen from the planning team, external or internal, and documents reflecting performance references may be expressed in general terms or in project specific expressions. In order to enable an environmental assessment to relate to such performances, these have to be expressed in very clear and unambiguous terms, also the identification of a set of relevant indicators and target values for these indicators, can be outmost useful.

Sources for performance references may be items that are included in legislation / regulation, the clients brief, routines and targets in the project team, or may be determined from the project itself. Targets may address performance on all system levels, from single materials or products, through functional components to entire buildings and groups of buildings. In those cases where targets are identified on higher system levels, but where the object of assessment is addressed on a lower system level, these targets will have to be broken down to the appropriate level, or the object will have to be assessed in a relevant context.

The identification of relevant performance levels or targets and indicators is an indispensable step foregoing the assessment procedure, as all assessments will make reference to these choices. The standard procedure does not promote certain sets of indicators, the design team will have to identify these; possibly relating to relevant literature in the field of sustainable construction.

DATA SOURCES AND FUNCTIONAL EQUIVALENCY

When applying the procedure it has to be recaptured that the direct comparison of alternatives may not be useful. Where a decision taker in general terms may apply LCA in order to compare two product alternatives more or less directly with each other, the building context of alternative materials, products or components requires that the decision taker assesses the functional equivalency from the buildings' perspective. Therefore, a change in one point of

the design my necessarily lead to an adaptation of the entire context of that change, also meaning that a comparative assessment of two alternatives on the material or product level may be insufficient.

acquired data and generated data

The procedure is based on the assumption that LCA datasets for the initial life cycle stages of various building materials and products are, or soon will be, available. In this context a clear call is being made for such datasets to fulfill the requirements as established in ISO TR 14025 on environmental declaration. For the assessment process, and in order to cover the entire life cycle, it will be necessary to complement such data with scenarios for the service life duration, which can to great advantage be obtained from the service life planning process within which this environmental assessment procedure takes place.

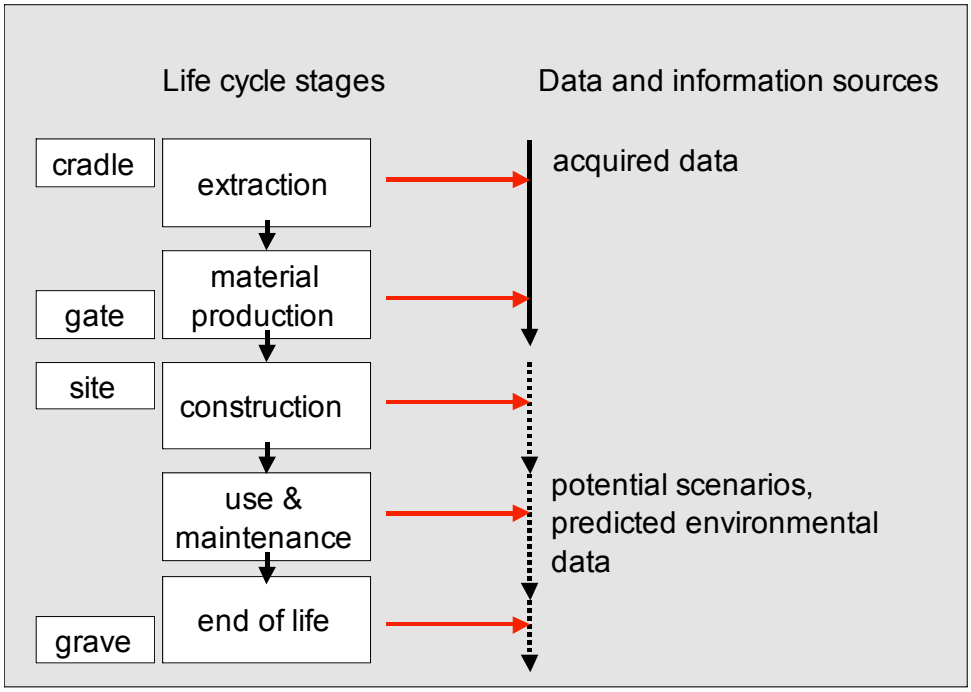

Fig 1: Life Cycle Stages and Data Sources

The data sources and the flow of information can also be illustrated in the figure below:

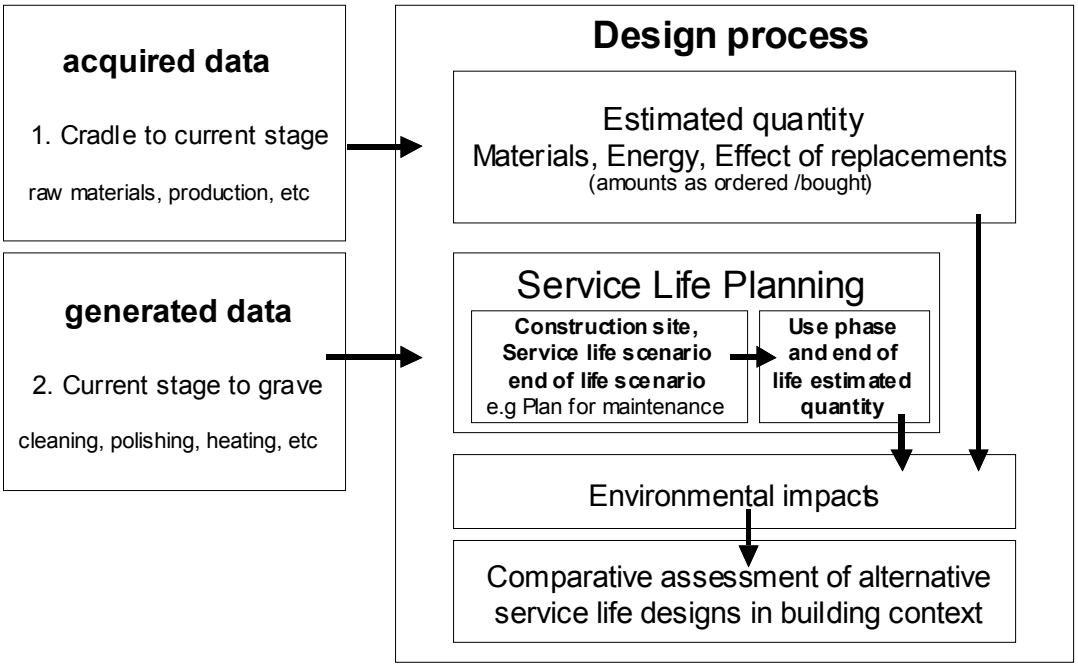

Fig 2: The interrelation of LCA data and Service Life Planning Data in the context of ISO 15686-6

Environmental impacts of products usually originate from all activities during all life cycle stages of that product. Without intending to stipulate any completeness, these are:

- Raw material extraction
- Product manufacturing
- Asset construction
- Use and maintenance
- End of life

The above, as well as e.g. all transportation occurring in-between the locations at which the involved processes take place.

ENVIRONMENTAL ASSESSMENT

The object of the assessment is to be assessed towards the identified performance references, as this will enable a project specific assessment of the option at hand. This requires that such performance references are established specifically for the project at hand, and that they are identified in a format that enables the environmental assessment to relate these references. The identification of environmental loads shall follow the methodology of Life Cycle Assessment, as established in ISO 14040. Concerning the data, the above has described that the context of application may have to be included into the assessment in order to ensure that alternatives with equal total functionality are compared with each other. Also for this identification, clear definitions of performance references have to be found, the discussion of surplus functions would lead too far at this point, as also all other methodology issues, such as e.g. allocation are not addressed in the standard procedure of ISO DIS 15686-6.

For the identified design, data will partly be available in terms of "part LCAs" or in terms of environmental declarations. For later life cycle stages data will have to be generated, reflecting the in-use situation of the design. All the necessary methodologies are subject of

international standardization, meaning also that there are methodologies available to actually perform the necessary tasks without involving excessive subjectivity. After having identified the object and after having put together the inventory data and performed the LCA impact assessment step, the question of valuation of the results will have to be addressed in some way. Usually valuation involves a great deal of subjectivity, which is often considered to be unreasonable when discussing results publicly. In this specific context, the question can be solved by performing an evaluation of design alternatives that is clearly related to targets and goals or indicators that have been established by the project team and specifically for the project at hand. In other words, this leads to a project specific evaluation, which is based on the project goals that were derived from the legal, economic and physical context of the actual project.

CONCLUSION

It is assumed that with this standard procedure it will be possible to include environmental impacts, based on a project specific assessment procedure, as equal part of decision taking, enabling a verification of the environmental status of a planned asset at the same time as performing technical and economic assessments for instance.

Enabling project specific assessments will also mean a departure from the critique general material and product assessments have to confront, as they face difficulties when having to address project specifics, no matter whether being of technical or valuation nature.

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From Vision to Built Sustainability? Review of 3 examples from Bo01

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ABSTRACT
The building exhibition "Bo01" in Malmö intended to establish Europe's first sustainable city. Reaching sustainability, in terms of "human sustainability, ecological sustainability, social sustainability and technical sustainability" was the very ambitious vision that had to be translated into documents underlying the planning processes for buildings to be erected on the site. A number of evaluation projects is following up the targets and means with which the exhibition tried to reach its target, as well as analyzing results. For three chosen projects it is here tried to identify the inter-linkage of exhibition and project targets, content in documentation and influence on the realization of these three building projects. Between the three projects, differences in overall building concept, as well as in the organization of the involved project and construction teams are substantial. At hand of these three building projects, a review of the initial goals and intentions identified prior to the planning and building process are reflected with the realities during the realization. Where did the vision succeed and where did it fail? How did the idea of sustainability influence actors in the building projects? A review of three examples can not give sufficiently well anchored evaluation results, but some tendencies can be filtered out of the impressions from visits at the exhibition and interviews with involved parties, paired with a rough descriptive analysis of these three buildings.

KEYWORDS
Sustainable Building; vision to reality; demonstration project; documentation; realization; project management

INTRODUCTION
During summer 2001, Malmö hosted "Bo01", the first European Building exhibition. The initial idea and concept for the exhibition stem from 1995, the decision on locating it in the western harbor area in direct proximity to the existing town center was taken in 97 and the planning processes started in 1998. The initial vision of a sustainable city is developed into the first ideas of the disposition of the area and an explanation of the vision of the "city of tomorrow" (Bo01 Framtidsstaden). In cooperation with the City of Malmö and representatives of the building sector, the Bo01 organization has developed a quality plan that aims to generate a common basis in order to build "the best district to be built in Sweden during 2001". The starting point for the development of the quality plan is the "realization of the necessity to build an ecologically sustainable information and welfare society" (Bo01 Kvalitetsprogram). The quality plan identifies and establishes targets to be met by the developers that are active within the premises of the exhibition area. The Swedish government declared 1996 that "Sweden shall be a driving force and an international model country in the intention to establish an ecologically sustainable society" also including the target to deliver to the next generation "a state of the country where the large environmental problems are

solved", resulting in a parliamentary note "towards an ecologically sustainable society" (Swed Gov 1997). Consequently established was a "local investment program" providing funding in order to support local Agenda 21 work of communities. Malmö has used this source of funding for the provision of financial support for special adaptation of buildings to be erect in the Bo01 area. Also the evaluation of Bo01 is mainly financed from that funding.

The investigation and evaluation work underlying this article is part of a larger evaluation project, with separate parts investigating into the subject of sustainable welfare and ecological modernization, environmental plans in demonstration products, project management tools and the information flow between involved actors, energy performance and material and product selection. The work is currently ongoing; a final report is intended to be published during summer 2002.

The scope of the here discussed evaluation project lies within the field of instruments for planning, project management and evaluation, all under consideration of environmental aspects.

ENVIRONMENTAL INFORMATION IN PLANNING PROCESSES

When addressing environmental aspects during the planning phase, when choosing materials, components and products to be included into the overall building design, the planning team needs a well-structured procedure, if the demands for documentation shall be met. Together with the quality plan, the demands of the building owner, as well as legal and administrative requirements, have to be met. These demands, paired with performance requirements originating from the construction into which the material is to be included, can be developed into a profile of properties and into reference values to which design alternatives can be evaluated. Choice criteria may originate from different spheres of performance interests, mainly to be mentioned are technical/functional, economic, environmental and aesthetical aspects. Where decision takers are used to incorporate the classical topics into their decision taking, the consideration of environmental aspects is still demanding efforts.

ISO is currently developing a routine for the consideration of environmental aspects within the context of service life planning for buildings and constructed assets (ISO 15686). But even when having methodological frameworks, such as LCA (ISO 14040) or other environmental assessment methods, in place and operational, the decision taker needs access to relevant data and needs targets to address. Especially striking is the problem of communicating environmental performance when no established priorities or indicators exist to relate to. The decision taker has to compare information originating from different sources; without a clear conception of the issues to address and without references that enable some form of ranking of available options, apparently a task that is solved by relating to more rudimentary evaluation references.

The origin of targets to be addressed by a building project may be of two kinds, either from external expressions, like in this case originating from legal requirements, building regulation or from the targets of the exhibition. Internal origins may be at hand in case the involved organization(s) has / have documents that include aspects of environmental performance of the organizations products or services. Such documentation may originate from the existence of an environmental management system, or from other company internal policy documents. The mentioned examples show a further difference, targets may have a generic character, meaning that the targets are to be achieved by any building project the company is involved in, or they may be specifically identified for a certain project. Based on the impression that

the three investigated projects left, it seems to be most promising when generic internal and external target documents are interpreted into project specific target documents.

External target setting
External targets are items that originate from definitions outside of the current project or planning team. To be mentioned in this category are targets and performance levels identified in legislation, regulation, standardization, common practice, and such. Also the demands of the client may be considered as external targets. In the context of Bo01 there was an additional organization present; as the organizers of the exhibition, this organization had to ensure that the buildings present at the exhibition would exemplify and illustrate the topic of the exhibition.

The Bo01 quality plan listed numerous items that were to be considered as obligatory targets by the planning teams. However, a system for sanctioning in case of non-conformance was not established. Concerning environmental aspects of materials and products, the quality plan consisted of a combination of simple criteria, like for instance the energy class that refrigerators had to fulfill, but also less straight forward issues like the demand that the planning team would produce material plans and have them approved by the Bo01 organization before proceeding with construction of the planned building. Further, materials and products should be evaluated and documented concerning their environmental performance, preferably by application of LCA (Life Cycle Assessment). Materials containing substances mentioned on the observation list of the Swedish National Chemicals Inspectorate (Kemikalieinspektionen) (KEMI 2002) are allowed only when special reasons can be well motivated.

Concerning to which references material plans would be approved of or not, could not be determined from the quality plan. The planning team was considered to plan a building, identify and specify materials and products and produce the material plan before purchasing the products. Any references for approval and mechanisms for adaptation to non-approval was lacking in the plan. However, this lack proved to be irrelevant, as due to the pressed time scale between project initiation and the opening of the exhibition, in combination with an economic situation of the organization, the material plan and the documentation and evaluation of materials and products was not followed up by Bo01 and Malmö city administration. As a consequence, the establishment of material plans and the documentation of material choices did not take place prior to construction.

Internal environmental targets and routines of organizations
Despite the lack of clearly established Bo01-target values, the existence of participating organizations' internal routines for environmental management and the project specific target documents that these organizations have prepared for their buildings on the Bo01 area has however lead to a consideration of environmental aspects.

Documentation about the process of considering environmental aspects appears to be varying in dependency of the organizational model of the project consortium. The larger the participating organizations, the more developed are generic internal routines, targets, information sources and guiding information. The more split a project consortium is, the larger the risk for conflict of interests and the higher the demand for the establishment of project specific target documents, in order to keep the group to pull the project into a common direction and to unify the various actors behind a common goal. The smallest "consortium",

where the architect was also coordinator, developer and project manager showed that such an organization might not even have the internal demand for documentation.

LEARNING FROM BO01

It appears that all involved actors in Bo01 have considered environmental aspects. Those aspects that were in detail specified and expressed with targets could be realized rather successfully. Other targets, as the overall consideration of environmental impacts in the choice of materials are very difficult to follow up and the verify, as there have been no clearly expressed targets to address, no identified priorities, no guidance for decision takers to relate to. Environmental aspects have however been addressed partly successful, where the participating organizations had internal targets and routines to be followed. The combination of the quality plan and other target documents has in some cases been developed into project specific environmental target documents, on the initiative of the project team. These team internal goals have been addressed and followed up internally, the driving force coming from the inside of the group rather than from the targets and monitoring procedures of Bo01.

A first developed lineout for the evaluation (Trinius 2001) as well as the emerging ISO standard 15686-6 and other literature in the field, e.g. (Sterner 1999), clarifies the need for clearly established goals that the planning team has to meet and can address and relate to when choosing products and materials. From Bo01 it can be learned that a quality program can only be successful in those parts, where targets are clearly formulated, where the significance or the reasoning is made clear to other actors, where the plan can be compared to the target and where it is enabled that the planning team can perform an evaluation within the planning process. The clearer a target is formulated, and the clearer a responsibility is given, in combination with routines for monitoring the process and the results from the party of the exposition organization, the better the results are. In the case of Bo01, this means that:

- The energy performance target was clearly identified and given reason for, actors could investigate their planned building's performance by application of standardized simulation and calculation models and by that ensure to conform with the target. Depending on differences in the basic anticipations and mistakes in modeling or calculating, inclusion of e.g. thermal bridges, internal gains and solar gains etc, deviation from the target however exists (Nilsson 2002).

- Green points, a list of features from which each project had to choose at least ten, were easy to include, even though the environmental relevance of different measures may have been unclear or at least incomparable with each other.

- Environmental impact from materials and products, which was to be determined by the decision taker and to be documented and included into decision taking, was difficult to implement. Target values were neither set in relative or absolute terms, except for qualitative statements. All actors can be said to have included environmental aspects in their thoughts when making basic design decisions, however only in few specific cases an environmental assessment has been carried out. There was no monitoring of environmental performance from the side of Bo01.

CONCLUSIONS

When developing the quality plan, the organization has identified an interpretation of the sustainability concept based on two spheres of sustainability, ecological and human sustainability. This deviation from the established UN concept consisting of ecological,

economic and social sustainability (UN 1987) may appear somewhat confusing, it originates however from the Swedish governments addressing of ecological sustainability, which the exhibition initiators aimed to pair with human sustainability. The result is that architectural quality plays a central role in the concept.

Comparing the content of the quality plan to various listings of "sustainable building" issues clearly allows to say that the quality plan has been addressing those issues that are commonly considered as being part of environmental sustainability. The lack of clear targets makes it difficult to analyze and assess performance of different buildings in the exhibition. Interviews with involved architects and other actors have shown that generally environmental aspects have influenced the concept for the building. Leaving the interpretation to the involved actors has however led to a wide spread of materials and construction concepts present in the district, common is only, that all parties use environmental justification for whatever choice they have made. The opposite way of influence, how environmental demands and targets have led to the choice of certain constructions and materials can rarely be found.

As a final statement, this implies that environmental aspects can be successfully addressed, when:

- Clear targets exist
- Involved project teams can be enthused and involved
- A common basis for comparison of options (simulation models) exists
- Responsibilities are assigned
- Targets are followed up and defended
- Involved actors see environmental performance as beneficial rather than as an additional burden to be considered within a pressed budget and time scale

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Sustainable district housing
- demonstration houses in Grong

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1. INTRODUCTION

Norwegian house building industry has up till now shown little interest in increasing the overall insulation level of their houses. The housing industry believes that the market want as cheap houses as possible. A large share of house buyers are however, willing to invest in hydronic based floor heating, even though this is not cost effective in Norway. The motivation for this investment is the extra comfort achieved by floor heating. In the advertisement children are shown playing naked on tile floor. Another benefit with floor heating is the flexibility for furnishing with no radiators or panel ovens along the walls. Extra insulation of the building envelope will, however, also result in higher comfort. Heating will hardly be necessary and the number of panel ovens will be minimized. Both heating costs and investment costs for the heating system will be reduced for such houses and they may therefore be cost effective in the long run. A market for highly insulated and cost effective houses will, most likely increase if good examples are shown and if the housing industry is marketing such houses. To develop such houses a project is carried out in co-operation with Grong municipality, a local architect, a local housing company, a housing finance institution, a governmental energy agency and a research institution. These different actors of the housing marked will work together to develop environmentally friendly houses that both are cost effective and marketable.

The objective of this project is to develop a concept for a cost effective row-house with energy demand that is 50% lower than for a row-house built according to the Norwegian building code of 1997. This will be achieved by the use of heat recovery on the ventilation air, by increasing the insulation level of walls, windows, roof and floor, and by using energy efficient appliances. A pre-study is carried out to estimate the costs for a house that meet these demands. Different ways of building thick building elements, robustness in relation to production, transport, mounting, and storing has been evaluated. Consequences for mounting the windows in thick walls and consequences for connection of building elements and installation of equipment have also been discussed. An important goal has been to minimize the cost of the heating system.

This paper will present the pre-study that was carried out during January and February 2002. For the main project a final concept will be designed and built in Grong. This concept should have a

sustainable design that includes the use of solar energy, a healthy ventilation solution, and the use of environmentally friendly materials. The house should also be robust and sensitive to user habits.

2. DEMONSTRATION HOUSES IN GRONG

Ten to twelve row-houses will be built in Grong during the fall of 2002 and spring of 2003. Grong is a small municipality with 2600 inhabitants located in the middle part of Norway, 200 km north of Trondheim. The area has inland climate with nice temperatures during summer and quite low temperatures during winter. The annual mean temperature is 4°C and the location is at latitude 64°N. The row-houses will be built close to the centre in a area called "Øvre Nausthaugen". One of the important measures for this project is to increase the exploitation of the central area. A new site plan is therefore being designed. Each row-house will be about 110 – 120 m² divided on two floors. Three house units with tree or four row-houses in each unit will be built.

3. LOW ENERGY ROW-HOUSES

To achieve 50% reduction in energy demand the following solutions will be used:

- Balanced ventilation with heat recovery
- Extra insulation of windows, walls, roof and floor on the ground
- Electric heating with thermostat
- Energy efficient lighting
- Energy efficient appliances
- Water saving equipment on domestic hot water (DHW)

The main focus of this pre-study has been on the building envelope. Technical installations and appliances are, however, also discussed.

The windows have a U-value of 1.0 W/m²K (the requirement of the building code is 1.6 W/m²K) This window has three layer glazing and two LE-coatings. For the walls two solutions have been evaluated. The first solution has 300 mm insulation. 250 mm I-profiles and 50 mm extra wall on the inside for location of electric cables. The U-value of this construction would be 0.13 W/m²K. (the requirement of the building code is 0.22 W/m²K) The extra cost for this solution was however too high. To reduce costs an alternative with 250 mm insulation was evaluated. A composed wall with 36 x 198 mm studs and additionally 36 x 48 mm studs for the extra wall were proposed. The U-value of this construction would be 0.16 W/m²K. For both the solutions the vapor barrier is placed between the main wall and the extra wall. The electric cabling is then prevented from puncturing the vapor barrier.

The roof will have 400 mm insulation and a U-value of 0.10 W/m²K (the requirement of the building code is 0.15 W/m²K). The floor on the ground will have 250 mm expanded polystyrene and a U-value of 0.11 W/m²K (the requirement of the building code is 0.15 W/m²K). Leakages and thermal bridges have to be minimized compared to existing requirements to prevent that the effect of the extra insulation is disturbed.

Mechanical balanced ventilation with heat recovery with efficiency of 85% is used. Because the heating demand is very low for this project, electric heating will be used. The power demand is

3000 W, half of what row-houses normally would need. Advanced control system with temperature reduction at night will have very little saving effect in these houses. To increase the "sustainability factor" and introduce renewable energy, a solar collector for heating of DHW will be evaluated during the main project. Water based floor heating might then be used for the bathroom floor. Since the heating demand is very low for this house, floor heating in other rooms will hardly be used. To increase the flexibility and emergency preparedness, the use of biomass will be evaluated as backup heating. Traditional wood stoves will probably be most popular for district houses, but this will assume a very high performance of the stack damper with low infiltration/exfiltration losses. A more contemporary solution would be to use a small bio pellet- or gas oven with a simpler smoke exhaust canal through the wall.

Energy efficient appliances with A-classification (EU-label) will be used when this is available. For a family of four with two adults and two children, the energy saving by using efficient washer, dryer, dishwasher, refrigerator, and freezer is estimated to be about 20% compared to normal appliances. Energy saving lighting equipment will reduce the electricity demand for lighting with 50% and water saving devices will reduce the energy demand for heating with 40%.

4. COSTS

4.1 Extra costs for super insulated building envelope and efficient equipment

The extra costs for this super insulated building envelope have been calculated by a house company involved in the project. Extra cost for materials, labour costs during prefabrication and on the building site, and extra costs for transport, is included. Normal profit and taxes are also included and the estimated costs should therefore be realistic. The costs are, however, related to extra costs for a standard house for the company involved.

Table 1 Extra costs compared to a standard house from the involved housing company.

Construction	Pr. m², NOK	Pr. row-house, NOK	Pr. row-house, EUR	Unit with 4 row-houses, NOK
Wall alternative 1, 300 mm insulation	450	40 000	5 360	160 000
Wall alternative 2, 250 mm insulation	185	16 500	2 210	66 000
Roof, 400 mm insulation	50	3 000	400	12 000
Floor on the ground, 250 mm	112	6 780	910	27 100
Window, three layer glazing, U = 1.0 W/m²K	1 390	18 350	2 460	73 400
Exterior doors, U = 0.85 W/m²K	295	1 180	160	4 720

Total extra costs for the first alternative with 300 mm insulation in the exterior walls are: 277 220 NOK for a unit with four row-houses, and 69 300 NOK (9 300 EUR) for each row-house.

Total extra costs for the second alternative with 250 mm insulation in the exterior walls are: 183 220 NOK for a unit with four row-houses and 45 800 NOK (6 140 EUR) for each row-house. This alternative is the most cost effective one and will be used in the following calculation.

Extra costs for mechanical balanced ventilation and a heat recovery unit is estimated to be 20 000 NOK (2 680 EUR). The costs for A-classified appliances are for some cases lower than for normal appliances. As an average the cost difference is therefore considered to be insignificant. Extra costs for energy saving lighting features will be in the same range as the cost for the energy saved by using such features.

4.2 Reduced costs for electric heating system

A Norwegian electro entrepreneur has calculated the costs for electric heating systems for the row-houses. Three alternatives are calculated:

1. Panel ovens with thermostats for the reference house built according to the Norwegian building code with a heating demand of 50W/m² (6 000 W pr. row-house).
2. Panel ovens with thermostats for the low energy house with heat recovery on the ventilation air and a heat demand of 25 W/m² (3 000 W per row-house).
3. Panel ovens with a central control unit for programming of reduced temperatures in each room for the same heat loss level as alternative 1.

Table 2 Estimated costs for electric heating

Alternative	Pr. row-house	Cost pr. row-house incl. tax, NOK (EUR)
Alternative 1.	reference , 6 000 W	16 120 (2 160)
Alternative 2.	low energy, 3 000 W	5 950 (800)
Alternative 3.	reference with central control, 6 000 W	22 940 (3 070)

The cost difference between electric heating for the reference house and the low energy house is 10 170 NOK (1 360 EUR) pr. row-house. A common request from house buyers is, however, heated bathroom floors. This will for both cases result in an extra cost of 10 000 – 15 000 NOK for two bathrooms.

4.3 Costs for water based heating system

Costs for water based heating systems are calculated with a computer program from Varmeinfo (see: www.varmeinfo.no) A water based system consists of a distributions system, a control unit and a heater. Total costs for a water based floor heating system for a 110 m² house is shown below. Costs for radiators are approximately the same as for floor heating.

Table 3 Estimated costs for water based floor heating for a 110 m² house.

Components	Estimated costs incl. tax[1] , NOK (EUR)
Distribution system in the floor	35 000 (4 690)
Control system	12 500 (1 670)
Heater (oil/el)	45 000 (6 030)
Sum	92 500 (12 390)

[1] Estimated costs include material costs, labor costs, and regulation of the system.

Table 4 Costs for different heat sources.

Heater	Estimated costs, NOK	Total costs for the heating system, NOK (EUR)
Oil/el	45 000	92 500 (12 390)
Biomass/el	50 000	97 500 (13 060)
Heat pump/el	95 000	142 500 (19 080)

4.4 Energy demand

Energy demand for the reference house and the low energy house is compared in the figure below. The energy demand is calculated for space heating, domestic hot water (DHW), fans and pumps, lighting and appliances. The specific energy demand is calculated to be 177 kWh/m² for the reference house and 86 kWh/m² for the low energy house. The specific energy demand for space heating is calculated to be 90 kWh/m² for the reference house and 25 kWh/m² for the low energy house.

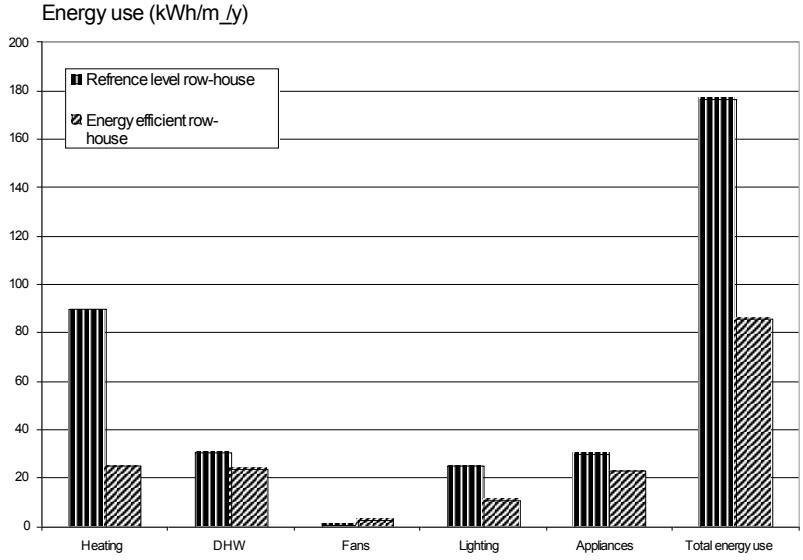

Figure 1 Energy demand per row-house (1/4 of unit with four row-houses) for the reference house and the low energy house.

4.5 Cost benefit

The total investment cost for the two solutions, the low energy house and the reference house with floor heating and heat pump, are compared. The low energy solution with balanced ventilation is called “The passive package” and the solution with hydonic based floor heating and heat pump is called “The active package”. Both these solutions release a grant from the Norwegian State Housing Bank of 10 000 NOK.

Annually saving of energy cost for the two solutions differ approximately 10 % and will be for the passive package with reduction from 177 to 86 kWh/m2: 5600 NOK/year (750 EUR/year), and for the active package with reduction from 177 to 96 kWh/m2: 5090 NOK/year (680 EUR/year). (energy price: 0,55 NOK/kWh or 0,07 EUR/kWh)

Total investment cost when 10 000 NOK (1 340 EUR) grant is subtracted:

The passive package:

Extra costs for super insulated building envelope:	+ 45 800 NOK
Reduced costs for electric heating system:	- 10 170 NOK
Reduced energy cost:	- 510 NOK
Extra cost for ventilasion system:	+ 20 000 NOK
Grant for the Housing Bank:	- 10 000 NOK
Total investment cost:	*45 120 NOK (6 050 EUR)*

The active package:

Cost for water based floor heating and heat pump:	+ 142 500 NOK
Grant from the Housing Bank:	- 10 000 NOK
Total investment cost:	*132 500 NOK (17 740 EUR)*

In calculations of payback time, interest rent is included. According to the calculations the payback time for the passive package is *11 years* and the payback time for the active package is more than 100 years. Present value after 25 years for the passive package is 32 530 NOK (4 360 EUR) and present value after 25 years for the active package is - 60 735 NOK (- 8 130 EUR)

5. CONCLUSION

Water-based heating systems are essential for the use of district heating and for local heat distribution. For houses not connected to such heat supply, a water-based system can still be a good and environmentally friendly solution if a heat-pump, a solar collector, or biomass is used for heating the water. The use of natural gas can also be seen as an environmentally friendly solution compared to the use of oil.

A heat-pump that collects heat from the ground or from the sea can reduce the electricity demand for heating of space and DHW with approximately 50%. The use of a solar collector can reduce the electricity demand with 30-50%. The concept described above with increased insulation level, heat recovery from the ventilation air and with energy saving appliances will also reduce the electricity demand with 50% compared to a house built according to the Norwegian building code. Compared to a water-based system and a heat-pump, this solution is much cheaper and cost effective. Water-based floor heating are often chosen because of the comfort of warm floors. With wooden floors and no drafts, the "sustainable district house" – the low energy solution may also be very comfortable. An argument that is often used for water-based systems is the flexibility achieved and the possibility to use different energy sources. For houses in the district, biomass or wood stoves often have a natural position and will secure the flexibility.

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SolarBau: Energy Efficiency through Lean Building Concepts

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1. ABSTRACT

"SolarBau" is one of the major energy research and development activities within the framework of rational energy use carried out by the German Federal Ministry of Economy and Technology (BMWi). Started in 1995, the program is to continue for a period of 10 years. It consists of the presentation of 25 pilot buildings scattered throughout Germany in conjunction with an accompanying evaluation and information program called SolarBau:MONITOR.
Funding has only been provided at the design stage for additional investigations and energy simulations and for a thorough monitoring of the finished buildings. The absence of investment subsidies has ensured that all design solutions were implemented under representative conditions reflecting typical economic side constraints. The technical requirements for admittance of a building into the program involved anticipated total prime energy demand (heating, ventilation, cooling and lighting) of below 100 kWh/(m^2a). These ambitious goals can be achieved by means of what is referred to as a *"lean building"* – one which features excellent thermal insulation, optimized daylighting and a passive cooling strategy based on an integrated design approach that takes heat and electricity consumption into consideration. The paper presents a brief description and evaluation of a number of large-scale commercial buildings and summarizes results and experiences emerging from the project.

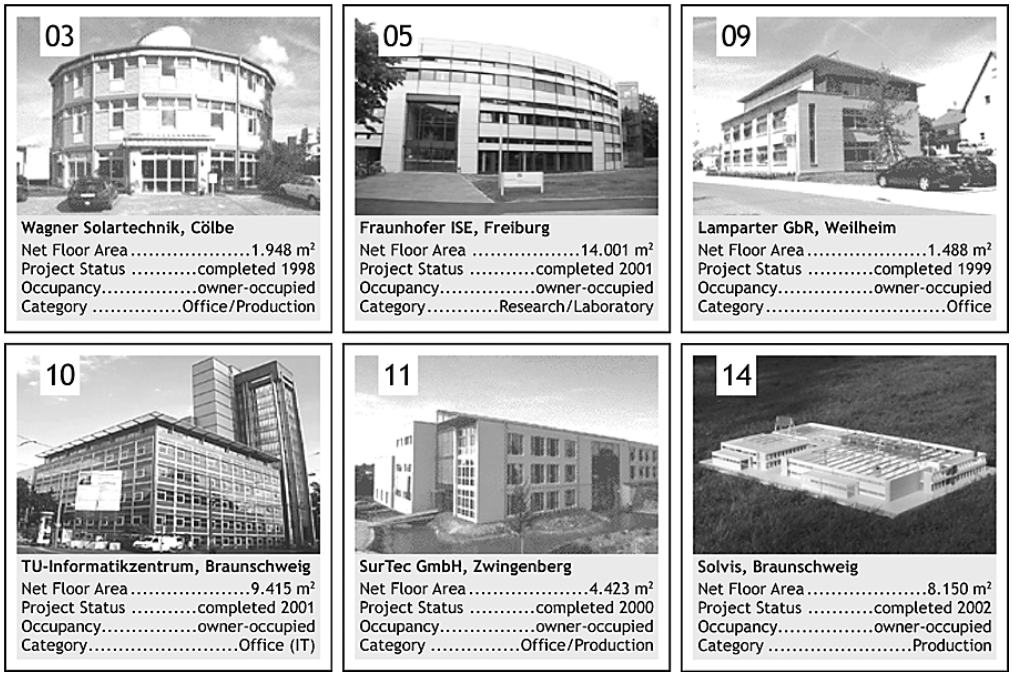

Fig. 1: Selected non-residential demonstration buildings of the funding concept SolarBau.

2. INTRODUCTION

Many so-called *intelligent buildings* are noteworthy for their large-scale technical equipment and the not inconsiderable amount of surface and volume use connected with it: suspended ceilings, double floors, twin facades, air shafts and central air conditioning plants frequently require between 20 and 30% of additional building volume. The support program SolarBau, with its call for the renunciation of active building air conditioning in the summertime, paves the way to "*lean buildings"* as prototypes for a successful synthesis of buildings and their engineering equipment. The demonstration projects are intended to incorporate current results of building research and indicate new paths to be taken. The cost analysis of the buildings show that it is possible to build in a cost-efficient *and* energy-conscious way by cost shifting. The funds made available for the demonstration projects will be particularly well spent if it becomes possible to disseminate the knowledge and experience subsequently gained from these research projects in such a way that they can have an influence on market developments.

3. STRATEGIES AND TECHNOLOGIES

Thermal Insulation

High-quality heat insulation is nothing unusual: it can be implemented both without requiring design compromises and at a reasonable cost. A number of projects reduce the energy-relevant A/V ratio of a building by means of glazed buffer spaces and count the atrium volume as being part of air supply or air exhaust spaces in concert with the overall ventilation concept. Careful testing must however be carried out on a case-by-case basis to determine whether this measure has a positive effect in terms of overall energy use. A real-world description of user behavior (opening of doors, utilization of shading devices) is necessary in order to avoid a too-optimistic evaluation. High-quality glazing simplify the heating engineering of the atria, in view of the fact that no additional effective heating surfaces need to be utilized, despite the large-scale glass surfaces. New ideas arising out of ongoing development efforts were taken up in the form of vacuum insulation inserts for door panels. This technology is beginning to be of special significance, because very positive insulation values can be achieved with minimal component thickness – a plus for those areas which do not permit the use of any large-scale insulation thickness. The long-term behavior of these products is thereby decisive for their potential applications in the construction industry.

Heating / Ventilation

High-quality heat insulation makes it possible to dispense with effective heating surfaces in office spaces and to make the transition to an exclusive use of air heating systems. The prerequisite for this is an exhaust air ventilation system including a heat recovery system. The experiences gathered during the initial projects of this type have yet to demonstrate whether user acceptance for this kind of solution can also be achieved in the context of small office units where individualized room air conditions are required. Individual room controls reduce the cost advantages of air heating systems. Even the most cost-effective combination of straightforward exhaust unit and decentralized ventilation by means of air vents in the building facades fails to achieve the extremely low heat requirement values of the "passive house" standard. For night ventilation in summer, however, concepts emerge which are interesting in terms of both economics and energy usage. The elimination of a duct network on the ventilation of intake air side represents a possible gain in terms of air hygiene.

Passive Cooling

The call for *passive cooling* is limiting side constraint – both for architecture and for building engineering. Proportionally speaking, the amount of surface glass used in the facades is necessarily less than that to be found among buildings with supportive air conditioning systems. It is only where there are external shading devices that the external cooling load falls

to a level which can be handled by passive cooling. It will fall to future projects to determine whether the new integrated or internal solar control systems can assume responsibility for this task in combination with special adjustable glazing. Nighttime ventilation (night flushing) has until now been the focus of efforts to remove heat from building mass. In cases of systems with mechanical ventilation, the electrical energy required to achieve cooling effects has been a critical figure. Air-based ground heat exchangers, which are now in widespread use, also make it possible to support a cooling of the building during the day – but the performance capacity of passive cooling still remains limited. Building concepts involving small to mid-sized office units are suitable for that reason. The possibility of being able to individually influence room air conditions increases acceptance of the inevitably greater temperature dynamics. New developments in the area of building materials with greater amounts of thermal capacity (structure-integrated phase change material, PCM) or computer monitors with reduced energy consumption (LCD technology) will lead to a considerable expansion of the area of applications for passive cooling. In terms of investment, passive cooling is often nowadays not yet less costly than classical air conditioning, although it involves a reallocation of costs from the building's technical equipment to the edifice itself. The economic advantage is to be found in any case in the reduction of energy-related operating costs.

Daylighting and Illumination

The early drafting stage has a significant influence on the amount of available daylighting. Planners often miscalculate the influence of limiting conditions by building constructions. The planning process should be backed up by light simulations and should be carried out with continuity in quality assurance. If the building concept calls for atria to assume responsibility for providing daylight to adjacent areas inside a building as well, then it is indispensable to have lighting calculations accompany the design stages. Glare-free daylighting coupled with outward visibility is virtually impossible to provide, particularly where there is direct sunlight on the building facade. The fact that many projects utilize external blinds with bipartite operating capability serves to underline how convincing their cost/benefit ratio is. An increase of the daylighting available in the inside of a building offers equal benefits in terms of both design and energy usage. This justifies increases in construction costs for glass in the interior area, even though the need for privacy is not to be ignored. Because the utilization of energy for illumination is granted greater importance in the context of the primary energy balance sheet for "*lean buildings*", all of the projects responded accordingly. Automatic adaptation of electric light to the available daylighting is more-or-less a part of standard equipment. User acceptance presumes individualized adjustment capability. In view of the fact that spaces with high levels of daylighting autonomy and efficient artificial lighting systems can also achieve very low consumption values for electrical lighting when coupled with sensible user behavior, it is worthwhile to implement critical examination of centralized automation installations.

Solar Energy Supply

Nowadays it is quite rare for solar energy installations to be included as a constituent part of an integrated building and energy concept. The drastic reduction of energy usage connected with the SolarBau projects makes possible the energy consumption-relevant usage of photo-voltaics: 1 m² photo-voltaic covers the electrical energy requirements needed to illuminate 10 m² of office space. It is interesting from an economic point of view that the Energy Saving Ordinance does not support the unit installations themselves but rather their yields. Room air conditioning through *solar cooling* is an additional, very promising approach to the reduction of fossil energy needs for the generation of cold. Initial installations in Germany are showing interesting results. Thermal collectors are particularly effective in cooling processes with low-temperature, e.g. based on open evaporation process with prior air drying. In principle, all of today's commercially-available collectors – including air collectors – could be put to use.

Monitoring

In contrast to everyday building practice, intensive monitoring is an important characteristic of demonstration projects. Monitoring has made it possible to detect faults in the functioning of systems and installations and to recognize optimization potentials within the installation control system. In view of the high energy usage involved with large-scale building projects, even minor changes in absolute numbers can lead to considerable energy savings.

Due to a lack of economic motivation, separate metering of energy flows according to individual consumer has not (yet) become standard equipment in new buildings in today's world. Post-construction determination of electricity usage according to consumer types such as lighting, ventilation or workplace equipment can only be achieved with great effort and expense. Most projects limit themselves to "representative" zones. Starting from the assumption that energy reference costs shall increase over the long term, and taking into account the new opportunities offered by communications technology (Power Line, Internet), solutions are being sought which use simple methods to provide transparency in the area of energy usage. Specifically-targeted measures with a high degree of economic efficiency will not be feasible until these have been found. The results of the surveys carried out in conjunction with some of the projects showed good conformity with the expectations based on the analysis of the measurement data as well as an extended qualitative estimation.

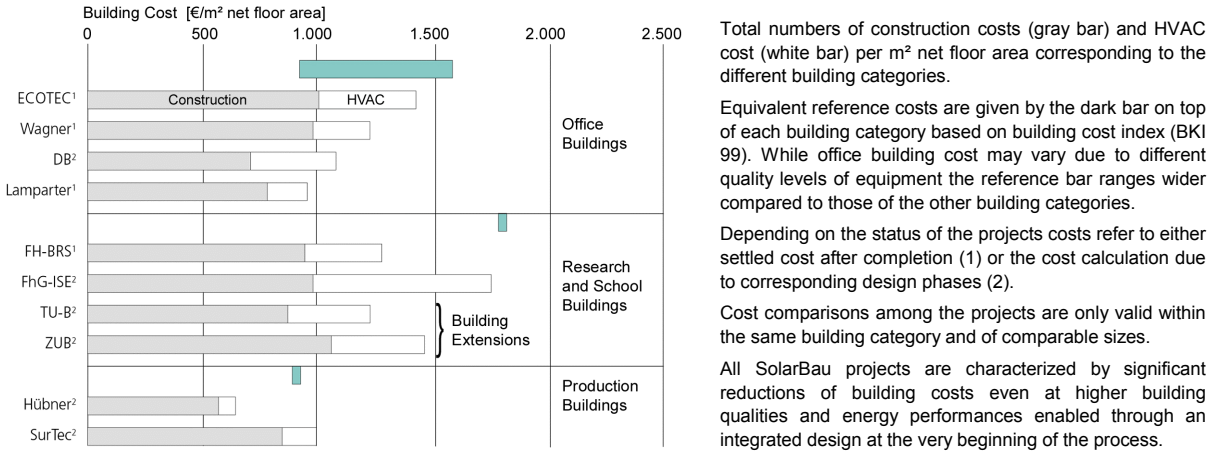

Fig. 2: Building costs of selected SolarBau projects compared to reference building types.

4. CONCLUSION

Energy-optimized buildings with characteristic primary energy numbers below 100 kWh/m²a can be achieved today with engineering technology which is both proven and available on the market. Given careful planning following an integrated approach, buildings can be constructed with high levels of utilization quality, outstanding comfort and low operating costs, without any increase in building costs. This means that high-efficiency buildings are economically superior to conventional ones. An operations technology survey and an optimization of operating behavior is to be recommended following completion of the building, in order to ensure smooth functioning of the building over the long term as well. Additional information regarding the model projects, complete with presentations and data comparing the buildings with one another, as well as additional notes concerning the support concept, are available at www.solarbau.de.

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IEA Task 23: Integrated Design Process (IDP) Guideline and Navigator

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1. ABSTRACT

Experience gained from energy-efficient and sustainable buildings demonstrates very clearly that ambitious goals require integrated design processes. This is especially true for non-residential building design, but an absence of knowledge and experience of integrated approaches remains widespread in the traditional planning community. Within the IEA research program, Solar Heating and Cooling (SHC) Task 23, led by Prof. Anne Grete Hestnes, Norway, a guidance system has been developed for that reason in order to provide sensitisation for creating bridges between "soft" design process issues and classic knowledge with management capabilities. This approach will create an opportunity for planners to develop their competency further, supported by generic guidelines and a computer-based interactive instrument called “Integrated Design Process (IDP) NAVIGATOR” [1].

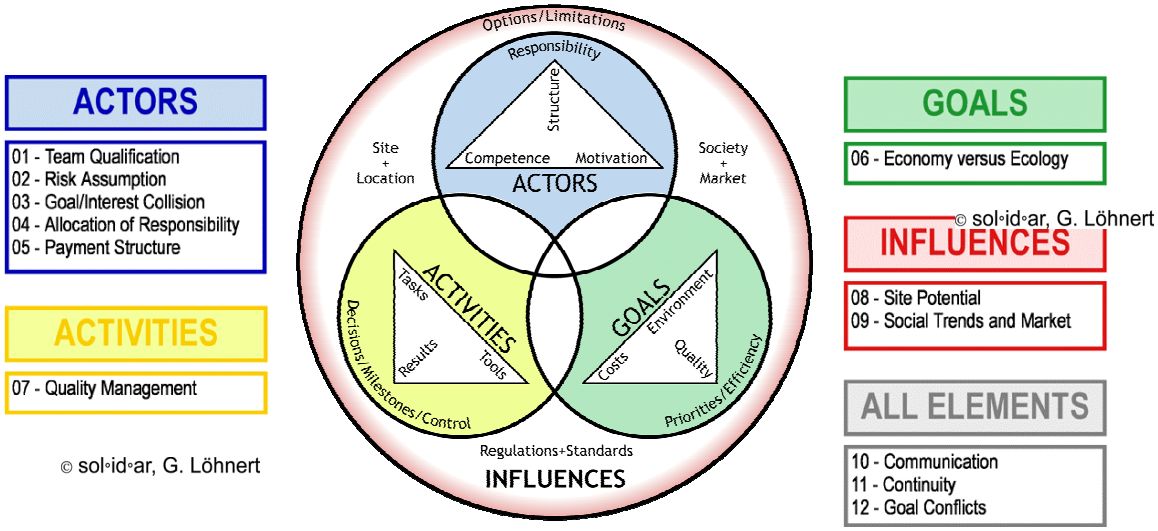


*Fig. 1: Interrelation structure of elements in the cognitive design process model. **ACTORS** represent the responsibilities and will determine the individual priorities of the **GOALS** in a project. Both will affect the kind and quality of **ACTIVITIES** needed to implement the right decisions at the right time. This triangle correlates intensively with individual project-specific **INFLUENCES** at different levels and in terms of different qualities.For each of the main elements Key-Issues have been identified and developed to recommendation check lists.*

2. FROM TRADITIONAL TO INTEGRATED DESIGN PROCESSES

The traditional process is related to the setting of task performances, generally in connection with corresponding fee structures. As defined by the professional associations of most countries, the traditional process is essentially linear in nature. Although details may vary from country to country, it usually begins with Project Definition, such as the preparation of a Design Brief and Functional Program, to be carried out by the client, followed by the first three phases of Pre-Design, Concept Design and Design Development, which are the responsibility of the design team.

Unfortunately, procedures and/or decisions frequently take place during the crucial transition phases from Design to Construction and from Construction to Operation that are at complete variance with integrated and sustainable design goals. These problems have been identified, analysed and transformed for generating a guideline structure and a set of recommendations.

3. IEA TASK 23 GUIDELINE DEVELOPMENT

Taking into account the results of international R&D projects such as Green Building Challenge, the Canadian "C-2000" programme, the IEA-Annex 31 "Energy related environmental impact of buildings" and "SolarBau", a German funding concept [2], the overall objective has been to develop the framework for an integrated design process guideline representing such "software" aspects of building design as phasing, methods and tools.

Basic Investigation

In the first stage, a number of analytic preparations were carried out in order to compile an array of essential information for structuring the entire complexity of integrated design. These basic investigations included the analysis and comparison of traditional design phasing and fee structures in different countries, the collection of case stories, the examination of working methods of architects and engineers, and the extraction of process related recommendations from existing guidelines on sustainable building design.

Context Analysis

A "common language" and a logical order for design processes provide the framework required to sustain the design iterations (loops) needed in order to optimise ambitious environmental project goals. A systematic consideration of typical design problems will structure these issues. A team of interdisciplinary planning practitioners developed the method of Context Analysis to illustrate the problems and difficulties of current planning and building conditions. This method takes into account the causal connection of problems, including their related backgrounds and reasons. Impacts and effects on the design process are analysed as well, providing necessary information and preparation work for basic solutions and final recommendations on different levels.

Cognitive Design Process Model

Interrelation Structure: An essential element of the examinations is a "thought model", which represents the structural basis for all planning work steps and which is also an important component for understanding and communication, not only for the user but also between the actors developing the instrument. The crucial elements during the course of the integrated design process have been identified and determined according to their relations with one another. Superimposition of the two analyses makes it possible to illustrate the interrelation structure (see Fig. 1).

Generic Process: The design process cannot be generated by simply following a recipe, but a basic structural generic process can be formulated which can then be adapted to the national specifications in each country. The main focus of this basic structure is the presentation of the necessary work steps and their interrelations, to include iteration loops for planning optimisation, as well as their interpretation and location in the process of design and implementation. In addition, the structure will help document progress and decisions made during the process.

Recommendations

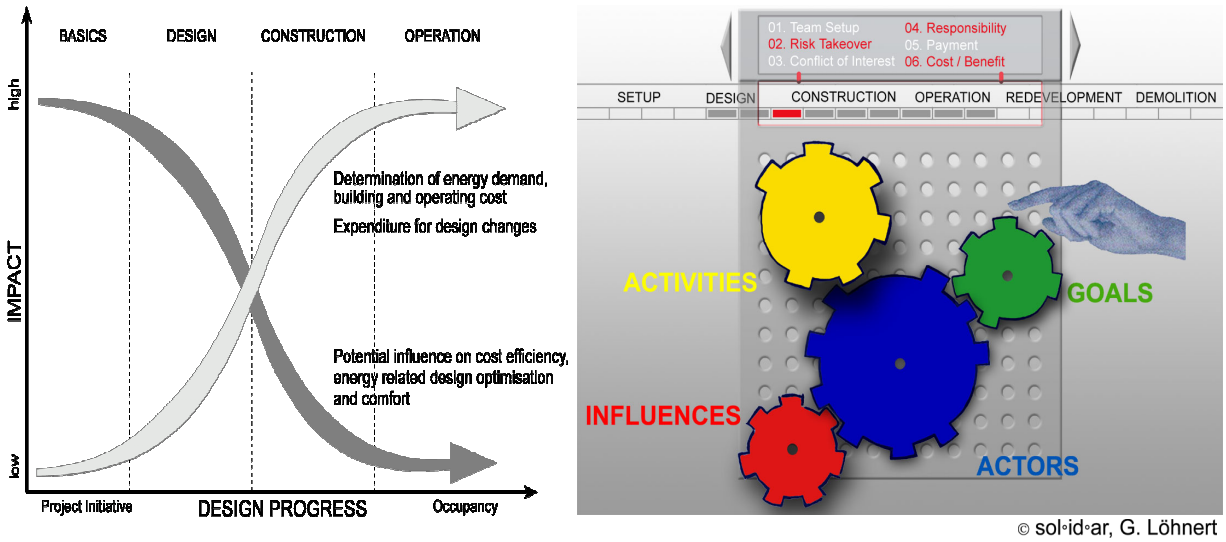
The groundwork and analytic considerations have as their goal the development of a guideline that systematically characterizes the concept of "integrated design" and describes the connections and interrelating mechanisms of different processes. The recommendations of this guideline are based on the method of Context Analysis. Together with experiences gathered from planning and building practice, all implementations are assigned to both the overall design process and its individual phases. The hints and advice offered address corresponding levels from general to detailed recommendations, from which a recommendation catalogue structured as an expanded checklist with several levels was then derived. Strategies and methods demonstrate how complex textual and organizational requests can be differentiated and how they can be influenced by individual planning actors. 12 "Key Issues" have been identified which describe crucial points and interfaces during the design progress (Figure 1). Each of the Key Issues is structured in a one page checklist format also providing navigation to more detailed information elsewhere in the electronic and interactive guideline. In addition, the checklist format of the Key Issues structure should be a source of inspiration and improvements for the process as a whole and promote awareness that design process optimisation is also be considered a component of the building project.

4. THE INTEGRATED DESIGN PROCESS NAVIGATOR

The function of the NAVIGATOR is to address energy-related/ecological and comfort-specific indicators relevant to the building design process. It can accommodate restrictions on structural characteristics and process features which have been identified and been incorporated into interrelations. A practice-oriented support of integrated design process requirements, interactions and complex information cannot be prepared without a computerized instrument. An efficient application of structured experiences and aspects has been fundamentally developed in a computer-supported instrument, the NAVIGATOR, for the integrated design process. It is intended to be an "early warning system" for the planner in order to be able to recognize potential problems in the process and to counteract them at the proper time.

The objective here is to develop the basic structure of a computer-supported planning instrument, its testing and the investigation of prerequisites for practice implementation. This structure offers a practicable preparation for the planner's individual integral planning process development, including its documentation. The design process runs from the first project initiative through the final assessment of building performance during the first period of building operation. The navigator presents this dimension in graphic form as a sequential workflow taking into account most generic tasks and iteration routines.

Besides the assignment of the tasks, an essential aspect within the development of the NAVIGATOR is the illustration of corresponding procedures and their interdependence. Transitions between individual phases are also of great importance, e.g. the transition from design to construction, since they usually represent a "point of no return" brought about by changes of responsibility and/or of actors. The integral design process NAVIGATOR acts as a generic multi-dimensional correlation structure which is to be developed according to the above-mentioned requirements to become an individual and interactive process generator for planning teams. In addition, the NAVIGATOR assumes responsibility for the description and documentation of decisions throughout the course of the entire project [4]. It is admittedly true that "recipes" for the design process are not intended or possible with this instrument. The NAVIGATOR should help to identify conflicts before they become problems and have negative effects on the contents and course of the design process. Seen in this way, it is less a control instrument than a directing catalyst which leaves the final decisions and responsibilities to the user. The contribution of the NAVIGATOR is the structuring and interrelating of the diverse aspects and know-how of the planning process as portrayed on different layers.



Figs. 2 and 3: Major impact on building performance during design progress: Only an early process intervention can take advantage of potential optimisation for energy and cost efficiency. Building cost and energy performances will approach definition as one enters the final stages of design development. Conceptual design alternatives are no longer possible at this point, and any attempt to implement a "repair design" will have quite the opposite effect in cost and time consumption.
Right-hand graph: Symbolic illustration of the interactive NAVIGATOR. Depending on project specs and design phases, the relevant key issues will be highlighted to provide recommendations.

5. CONCLUSION

Improving the qualifications of our design and building culture in the direction of sustainability can only be promoted by the conviction that this future responsibility is linked to benefits for all – i.e., that it is profitable. This represents an opportunity to reduce both investment and operating costs in favour of higher utilisation quality without compromising creative values.
Nevertheless, as long as the planning process, which can be referred to as the "software" of building activity, is not documented and as long as the integrated procedure is not performed by the actors involved, adaptation of individual examples for the current planning tasks of interested planners is either not possible at all or only under certain limitations. This holds true not only for current practitioners, but also for future architects and engineers studying at colleges and for their teachers as well [5].
The development of a guideline and a navigation instrument for the integrated design process should help close this gap: freely available and adaptable to individual projects, the computer-supported NAVIGATOR instrument will provide information, management and documentation capabilities. As an early warning system, but also as a control instrument and documentation tool, the NAVIGATOR will help to promote awareness of the necessity of integrated design processes and to educate the user in the opportunities of sustainable building design principles - not as a recipe book or even a teaching manual suggesting standard solutions that prevent the planner from thinking for him/herself, but quite the opposite: as an interactive tool promoting creativity and helping to open up new potentials and market positions for planners.

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Energy and Environmental Benefits of Alternative Work Arrangements

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1. INTRODUCTION

Between 1990 and 1997, the growth in the Canadian commercial sector secondary energy use was 13.4 percent - almost all to support the increase in floor space to accommodate growth in economic activity (Office of Energy Efficiency 2000). If the future growth in commercial energy use and greenhouse gas emissions is to be significantly reduced, then the *current rate of growth of floor space* to accommodate growth in economic activity must be seriously questioned. Given that the average office building's utilization rate is currently only 21 percent (Lloyd 1993), alternative work patterns which require less space for economic activity and use the existing building stock more effectively assume importance.

In 1997 the transportation sector accounted for 26.9 percent of secondary energy demand in Canada, of which 59.2 percent was due to the passenger sub-sector (Office of Energy Efficiency 2000). Between 1990 and 1997, the growth in the passenger sub-sector energy use was 6.8 percent, of which 70 percent was due to light vehicle road-passenger transport. If the growth in road-passenger transport energy use is to be significantly reduced then alternatives to the daily, singly driven automobile commute must be explored.

Alternative Work Arrangements (AWA) is a catchall phrase for strategies that make use of temporary desk space, laptops, cellular phones and beepers to eliminate or reduce the daily commute and the need for a permanent desk space at the workplace. Prime examples of AWA are *Hoteling* that result in 30 to 40 percent reductions in office space (Weil 1994), and and *Teleworking* that generally involve an average of 1-2 days of telework per person per week (Mokhtarian 1995). A US Department of Transportation study issued in 1994 predicts between 6 to 13 percent of the workforce teleworking by the year 2002 (Jacobs 1994, 92).

Alternative Work Arrangements allow a more effective use of office space, eliminates the need to commute *daily* to work and opens new opportunities to reduce energy use and related greenhouse gas emission. This paper examines the potential for energy use and greenhouse gas reduction associated with the use of AWA in a Canadian office building, considering:

- *Operating Energy of Primary Workplace*, i.e., usually the employer's premises.
- *Operating Energy of Telework Place,* i.e., location at which the employee and the employer have mutually agreed the employee will telework from, usually the "home office."
- *Commuting Energy,* i.e., energy used to commute from home to primary workplace

The paper uses a *more appropriate* unit of energy measurement, i.e., MJ/person/hour of work rather than the traditional unit of MJ/m^2/year in the attempt to directly relate energy use to a quantifiable rate of human activity.

2. CASE STUDY BUILDING

The Burnaby Fraser Tax Services Office (the "BFTSO") located on King George Highway in Surrey, British Columbia was completed and occupied in late 1998 and currently accommodates 612 employees. Seventy five percent of the employees work by an AWA:

- *Hoteling* arrangement is used by 129 employees from the Audit department. They are assigned 109 workstations (an employee to workstation ratio of 1.2 to 1).
- *Telework* arrangement is used by 46 employees belonging to the Audit and Collections departments. They are assigned 13 workstations in the BFTSO and each teleworker has a home office.
- *Compressed Week* arrangement is used by 256 employees. They have the flexibility to work four or five days a week to log 75 hours of work in a 14-day period.

Table 1: Summary of AWA in case study building

Type of AWA	Hoteling	Teleworking	Compressed Week
When started?	May 1999	Earlier to 1999	~1990
Number of users	126	46	256
Number of workstation	109	13	285
Ratio (users : workstation)	1.2:1 (current) 3:1 (optimum)	3.5:1 Primary Workplace 1:1 Home Office	1:1
How assigned?	4 Reservation Desks, Online	4 Reservation Desks, Online	Permanently assigned
Work at primary workplace	2 visits/week, Half/full day	1 day per week	75 hours/ 2 weeks
Work remaining time	From Client's office	From home	
Commuting pattern	Commute 2 days/ week	Commute only 1 day/ week	Commute 1 day less
Equipment with WS	Table lamp, Follow me phone	(Home Office): Laptop, printer, phone	PC, phone
Storage space	2 filing shelves, 1 mobile drawer, Central file storage	(Home Office): Filing Cabinet	Overhead storage bins, Central file storage
Mobile equipment	Laptop, portable printer	Laptop, portable printer	

3. ASSUMPTIONS FOR ESTIMATING OPERATING ENERGY

3.1 Assumptions for Primary Workplace (the BFTSO)

- *Intensity of Energy Use* (per unit area) was assumed uniform across the building.
- *Unit of Time* was taken as 75 hours (i.e., the number of hours an employee must work in a two-week, 14 day period) because 75 hours is the least common denominator of time for recording work activity across the different AWA's applied in the building.
- *Unit of Space/Energy Use* was a workstation. All employees use workstations and the estimated energy use per workstation can be converted into energy use per employee based on the ratio of employees to workstations. The workstations (WS) in the BFTSO can be subdivided into two categories: A and B.

Table 2: Summary of workstations in the official workplace

Category	AWA Used for	# of WS	Types of WS	Location	Area/WS	Energy (GJ)/WS/75 hrs
A	Hoteling, Telework	122	1 Type only	Floors 2,3, 4	15.4 (sq.m)	0.74
B	Comp. Week, Regular	483	Many types	All floors	17.8 (sq.m)	0.85

3.2 Assumptions for Telework Place (Home Office)

- *Total Area* of home office for energy calculations (including the work space, support spaces and circulation) was estimated as $25m^2$.
- *Location* of home office is in a single detached house with an average area of 237 m^2. The average household size is 2.6 persons. (The Sheltair Group 1999)
- *Average Period of Use* of home office is estimated as 48.5 hours in two weeks.
- *Incremental Energy Use of Home Office* considers several factors. Space heating is generally provided by a central furnace, which does not allow for separate heating of partial areas of the house. The pattern of incremental energy use for space heating leads to three possible scenarios.
  - *Scenario C1* assumes that another family member is at home during the time a teleworker is using the home office. The house is therefore already being centally heated and there will be no incremental heating energy for the home office.
  - *Scenario C2* assumes that provision exists to heat the home office separately from the rest of the house during the hours the teleworker is using the home office. The incremental heating energy is 25 m^2/237 m^2 or10.5% of the total heating energy
  - *Scenario C3* assumes there is no provision to heat the home office separately and that only the teleworker is at home. The incremental heating energy is therefore 100% of the total heating energy of the house. This is the typical situation.

4. ASSUMPTIONS FOR ESTIMATING COMMUTING ENERGY

The transportation pattern of the BFTSO occupants is derived from a survey conducted in 1998. The key parameters are the number of round trips of the respective work arrangements and the modes of travel used by the employees. The average kilometers traveled per round trip are assumed to be the same (50 km) across all the work arrangements. The distribution of the different modes of travel between the work arrangements is given in *Table 3*.

Table 3: Method of travel to work and number of roundtrips

	Hoteling	Telework	Compressed Week	Regular Time
Number of employees	126	46	258	152
Round trips/ 2 weeks	4	2	9	10
Single Drivers	70%	75%	60%	60%
Carpool	5%	-	10%	10%
Vanpool	-	-	5%	5%
Transit	10%	10%	10%	10%
Jog/Walk/Cycle	5%	5%	5%	5%
"Did not work"	10%	10%	10%	10%
	100%	100%	100%	100%

5. OPERATING ENERGY USE AND GHG EMISSIONS BY WORKSTATION TYPE

Table 4 gives a summary of the types of workstations and their energy use. The energy use is estimated for a year and then proportioned for two weeks (75 hours). This average value incorporates seasonal differences. The three scenarios of energy use for the home office workstation (C1-C3) differ only in the quantity of energy they consume.

Table 4: Summary of types of workstation and their energy use

WS Category	Work Arrangement Used For	# of WS	Energy(GJ)/ WS/ 75 hrs
A	Hoteling, Teleworking	122	0.74
B	Regular Time, Compressed Week	483	0.85
C1 (0% Incremental heating)	Home Office (house already heated)		0.12
C2 (10% Incremental heating)	Home Office (heat home office only)		0.17
C3 (100% Incremental heating)	Home Office (heat whole house)	46	0.63

The energy use of the home office, when the entire house is heated (0.63 GJ) is 15 percent lower than the energy consumed by a hoteling or telework workstation in the primary workplace (0.74 GJ). However the energy use of a home office is significantly lower (0.17 GJ) when the home office is heated separately from the rest of the house. The energy use per workstation in *Table 4* is used to calculate the total energy use of a work arrangement. Workstation type C2 is considered for the energy calculation of the home office. The total energy use of a work arrangement is then distributed over the number of employees in the work arrangement to obtain the energy use per employee of that work arrangement.

Table 5 analyses energy use and related greenhouse gas emission for the different work arrangements. The calculations consider a hoteling ratio of 3:1 (an optimum employees to workstation ratio) and the energy efficient WS type C2 for the home office.

Table 5: Total energy use by different work arrangements

	Hoteling	Telework	Comp. Week	Regular
Operating Energy (GJ)	0.25	0.38	0.94	0.94
Commuting Energy (GJ)	0.45	0.24	0.89	0.99
Total Energy(GJ)/ Person/75 hrs.	0.70	0.62	1.83	1.93
Operating GHG (Kg)	7.00	5.90	26.70	26.70
Commuting GHG (Kg)	33.16	17.42	65.93	73.26
Total GHG (Kg)/ Employee/75 hrs	40.16	23.32	92.63	99.96

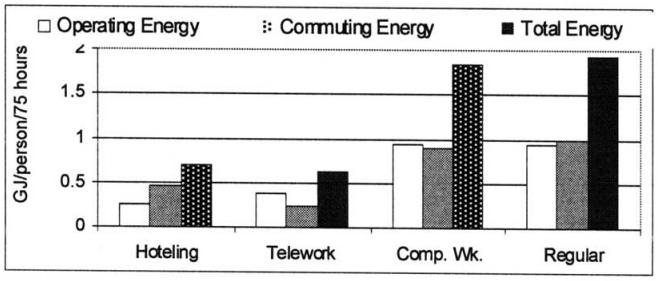

Figure 1: Total energy use per employee

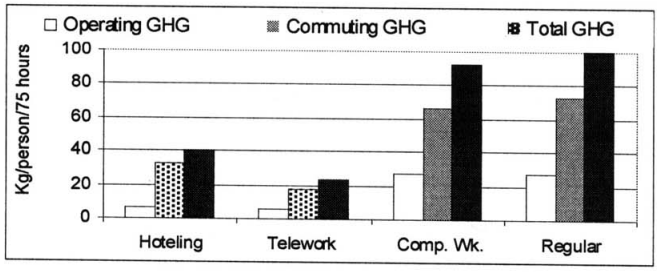

Figure 2: Total greenhouse gas emission per employee

The total energy use ranges from 0.62 GJ/employee/75 hours (for teleworkers) to 1.93 GJ/employee/75 hours (for regular time). The total GHG emission ranges from 23.32 Kg/employee/75 hours (for teleworkers) to 99.96 Kg/employees/75 hours (for regular time). More specifically the following conclusions are made:

5.1 Energy Savings due to AWA

- *Telework* is the most energy efficient work arrangement. An employee on telework will use 68 percent less energy (total of operating and commuting) than an employee on regular time arrangement. This can be further divided into a 60 percent reduction in operating energy and 75 percent reduction in commuting energy. The related greenhouse gas emissions will also be lower by 77 percent. Net energy savings per teleworker can be 34.06 GJ per annum. Corresponding savings in greenhouse gas emission can be 1950 kg per annum. Separate and efficient environmental conditioning of the home office is crucial to the energy performance of the work arrangement.
- *Hoteling* is the second most energy efficient work arrangement. An employee working by hoteling will use 63 percent less energy (total of operating and commuting) than an employee on regular time arrangement. This is further divided into a 73 percent reduction in operating energy and a 55 percent reduction in commuting energy. The related greenhouse gas emissions will also be lower by 60 percent. The use of hoteling workstations at optimum ratio (employee to workstation) is crucial to the energy performance of the work arrangement.
- *Compressed Week* arrangement benefits mainly from a 10 percent reduction in commuting energy compared to regular time arrangement.

5.2 Proportion of Operating and Commuting Energy

Commuting energy constitutes 38 percent of the total energy spent by an employee on telework (i.e., total of commuting energy and operating energy) whereas it constitutes almost 64 percent of the total for an employee using hoteling. Thus the commuting component varies significantly between the arrangements and can be higher or lower than the operating component. However due to the higher carbon intensity of automobile fuel, the greenhouse gas emission from commuting energy is higher for all work arrangements compared to emission from operating energy. For the work arrangements at the BFTSO, commuting energy is responsible for 75 of total greenhouse gas emissions wheras operating energy (of the BFTSO and the home offices) contributes only 25 percent to the total greenhouse gas emissions.

6. CONCLUSIONS

The analysis of energy use and greenhouse gas emission presented in this paper is based on Vancouver conditions of climate, fuel mix and commute distances. The smaller (percentage) contribution of greenhouse gas emission from operating energy, compared to commuting energy, is due to the high proportion of hydroelectric power (almost 95 percent) in British Columbia. The greenhouse gas contribution from operating energy will be considerably higher in regions with a higher proportion of thermal power (coal and/or coke).

Improving the environmental performance of officebuildings is obviously important. However, if reductions in greenhouse gas emission is the primary objective of energy conservation measures, then equal emphasis should be placed on commute trip reductions to eliminate commuting energy consumption. This observation is consistent with the options suggested by the *Transportation Climate Change Table* to reduce greenhouse gas emission

that identifies telecommuting and car sharing among the *most promising* measures to reduce emission from passenger transport. (Transport Climate Change Table 1999, 88)

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Decreasing a Buildings Operational Energy Costs through the Application of Building Physics Principles During the Design Phase

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The three authors have done the same amount of work with this paper

1. INTRODUCTION

Energy use in the building sector represents approximately 40% of the total energy use within the EU (Sjöström, 2000). The predominant part of this is related to the operational phase of a building project. The implications regarding the environment in addition to the economy, have led to an increased interest for energy conservation in buildings during all phases of their lives.

Building physics plays a key role in the design of energy efficient buildings. It is not always considered during the design of a building, yet it influences the energy use and thermal climate of a building over its entire life. Disregarding these principles can result in superfluous operational costs and environmental impacts.

This paper reports on an examination of a multi-family dwelling, built in 1998, located in Svedala, southern Sweden regarding building physics, indoor climate and energy performance. The objectives are to point out potential improvements and the resulting economic issues for this specific building and report the actual energy data and software for energy balance calculations.

2. METHOD

A modern, multi-family dwelling, layout shown in Fig. 1, was selected for this study. There is no basement or attic, no internal staircase or common heated areas in this building. The simplicity of this design was thought to make the energy calculations more precise by decreasing the uncertainty and the number of parameters. It is one of nine identical buildings located in the same area of Svedala. The typical outdoor temperature varies between -1 and 16 °C on average during the year and the difference between day-time and night-time is about 6 °C.

The construction consists of a traditional slab block frame of concrete cast *in situ* on prefabricated floor slabs with a brick clad, wooden joist curtain wall façade. The roof is a light structure of gypsum boards and mineral wool carried by timber trusses. The window area is 80%

on one length, 20% on the other with no windows on the gables. The particular building analysed in this paper has its 80% window area facing the north. The heat and hot tap water are supplied by way of hot water radiators. One exhaust condensing natural gas boiler located centrally in the building heats the water. A mechanical exhaust ventilation system removes air from the kitchens and washrooms. The intake is a simple slot in the wall located above each window. Each building contains eight apartments comprising a total of 520 m^2.

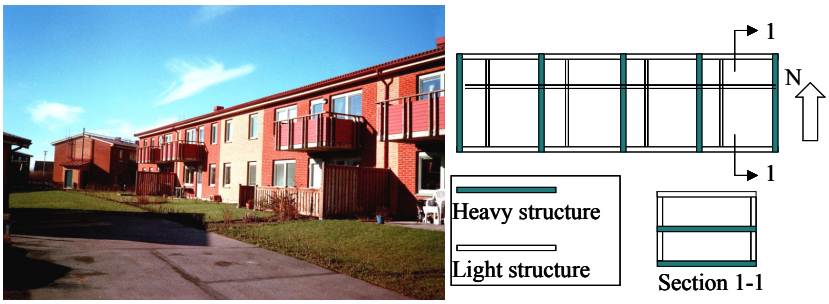

Figure 1 Multi-dwelling building Erlandsdal 1B in Svedala. Exterior (Facade), principal plan and section

Two apartments in the examined building were chosen for thermal imaging, air tightness testing and air flow rate metering. Apartment one is located on the second floor close to the outdoor roof and the gable of the building. Apartment two is located on the bottom floor in the centre of the building. The specific apartments were chosen due to the availability of the inhabitants during the time of the measurements.

The air tightness of the apartments was measured according to the Swedish standard SS 02 15 51 (SIS, Swedish Standards Institution) using a Minneapolis Blower Door, Model 3 outfitted with a C-Ring. The ventilation rates were measured according to the manufacturer's instructions for the Mätstos funnel and VelociCalc model 8355 air velocity meter apparatus. The thermal imaging was conducted using an Agema Thermovision 900, liquid nitrogen cooled thermal camera coupled to an Agema computer system. A Raytek Raynger MX4 advanced infrared thermometer was used to measure additional surface temperatures during the period the measurements were being taken. Glaser calculations were completed as outlined in Harderup (2000, 36-38) and the software package Heat2 (Blomberg, 2000) was used to analyse specific details of the drawings to determine the theoretical indoor wall surface temperatures, the effects of thermal bridging, and other possible design problems. The input boundaries for Heat2 were based on the outdoor and indoor temperatures measured on the day that the measurements were taken.

The actual use of energy for space heating and hot tap water as well as the electricity used for common areas over two one-year periods (2000 and 2001) were collected from the owner of the building, AB Svedalahem. Household electricity use for the year 2000 was obtained from the supplier, Sydkraft AB. The electricity readings were for the entire year, however the natural gas readings were available for each month. When the building was simulated, the different kinds of energy needed to be known.

Energy balance calculations were performed with two different software packages. They were 'VIP+' (Skanska IT-Solutions, 1996) and 'ENORM' (Svensk Byggtjänst). The advantages with VIP+ are one-hour time step simulations, modeling of air infiltration, solar gains and the influence of thermal capacity. The advantages with ENORM are its simplicity and that it is commonly used in Sweden. Input data regarding the technical characteristics were gathered from the construction documents and from field measurements. Data on internal gains from people and indoor temperature were estimated on the basis of the number of inhabitants. Internal gain from electricity was adjusted to the electricity bought by the households.

Parametric studies on the consequences concerning energy use and indoor climate were related to alternative designs concerning ventilation systems, the thermal capacity, air tightness, windows and the direction of the building. These simulations were performed with the energy balance programmes VIP+ and ENORM. Related impacts regarding life cycle economy were examined with Life Cycle Cost calculations where the present value method was used.

3. RESULTS AND DISCUSSION

3.1 Ventilation system

The results from a survey completed earlier indicated that the ventilation system was a weak point in these buildings. With regards to perceived indoor air quality and health related issues, the building and its services appear to be functioning well. However, cold air from the intakes above the windows generates dissatisfaction with the thermal comfort, especially during the winter. In several cases, the tenants have blocked the air intakes to counter this effect. This may result in creating a vacuum effect in the apartments, which in-turn explains why smells from the neighbours cooking are noticeable.

The ventilation rates were measured in the kitchen and washroom of both apartments. The initial flows set by Svedalahem for the kitchen and washroom were 10 L/s and 15 L/s respectively. These rates also conform to the minimum rates required for these rooms as set in the Swedish building regulations (Boverket, 1998). In apartment one, the measured flows were 6.3 L/s and 12.2 L/s for the kitchen and washroom respectively. In apartment two they were 9.3 L/s and 9.0 L/s respectively. These measurements follow Engdahl (1997), which shows that most ventilation systems in flats are quickly thrown out of calibration shortly after installation. In both instances, the flow rates are lower than the minimum required by law.

A parametric study was completed to show the influence in the Life cycle cost (LCC) if the system were a supply and exhaust system with a heat recovery unit. The initial cost would be three times the real cost, the maintenance cost would be higher but the energy use would be lower resulting in an equal LCC after 50 years. The LCC would be about 2040 SEK/m². The real rate of interest was 2% for energy and 3% for the rest. The heating cost was 0.46 SEK/kWh and the electricity cost was 0.65 SEK/kWh. Despite equal LCC, the indoor climate would be better.

3.2 Apartment air tightness

The air tightness in apartment one was measured to be 0.39 l/(s·m²) and apartment two was 0.22 l/(s·m²). Swedish building regulations require that the air leakage from a building must be under

0.8 l/(s·m²) therefore both flats are good in regards to air tightness. Apartment one seems to be normal however apartment two seems to have a very low number. This could be attributed to the fact that apartment one is located on the top floor and has a wood-framed ceiling, two wood-framed external walls and two concrete walls, only one of which is an exterior wall, and a concrete floor that has a heated flat under it. Apartment two, which is on the bottom floor, consists of only two wood-framed external walls, concrete walls towards neighbouring flats, a concrete ceiling and a concrete floor (insulated slab on ground).

If the tightness were increased, the energy balance with a exhaust system would not be affected as air leaks only substitute air through air intakes. With a supply and exhaust system with a heat recovery unit, a completely tight building would decrease the annual energy use with 3.5 kWh/m² compared to the average measured tightness and 6.2 kWh/m² compared to the regulated value.

3.3 Surface temperature aspects

With Heat2, the wood framed wall including the foundation and soil under the building was simulated in a steady-state environment using the actual temperature readings obtained in the field. This simulation showed the theoretical temperatures based entirely on the design of the walls, while the thermal camera showed the real temperature profiles. In this case the calculated values were accurate to within +3ºC of the measured values. This difference can be attributed to workmanship since the computer software calculates based on a perfect fitting structure.

3.4 Actual energy use versus calculated

Electricity bought by the eight households totalled 13914 kWh, which corresponds to 26.7 kWh/m^2. The gain of energy from the 16 people living in the building was calculated by assuming 80 W per person of released energy and that half of their time is spent inside the apartment, which gives 1.23 W/m^2. Common electricity used for the block corresponds to 2.5 kWh/m^2 and does not contribute to the energy balance as the related heat is released outside of the climate shell. Ventilation rates used in the calculations were 25 l/(s·flat) based on the final inspection rate. Figure 2 shows the annual energy use for the building.

Actual energy use for space heating and tap water heating in the actual building for 2000 and 2001 was 145 kWh/m² and 151 kWh/m². This is a bit higher than the average energy use 140 kWh/m², for new multi-dwelling buildings according to 'Miljövårdsberedningen' (2000). The use of electricity, 26.7 + 2.5 = 29.3 kWh/m² is a bit lower than the average 35 kWh/m² (Ibid). The energy use for space heating and tap water heating for the neighbouring houses were lower eventually because of a lower demand for hot tap water. The year 2001 had 12% more degree hours than 2000, which explains the difference in radiator heating need between the measured building and the calculated building.

If the need for radiator heating in the summer is zero, all the energy for June, July and August must go to heating the tap water. With that assumption, the tap water energy demand for year 2000 should be 95 kWh/m² and for 2001, 77 kWh/m², which are high values. The Trelleborg project (Johansson and Johansson, 1999) indicated 36 kWh/m² and the ENORM default value gives 46 kWh/m². More research is needed to find the reasons behind the high summer energy use. Possible ways could be to compare cold-water use for the different houses or to make gas

readings every hour and check the night consumption to point out possible leaks and extraordinary behaviour.

The calculated energy use depends a lot on the need for hot tap water. In this case, the energy need for hot water was unknown. Therefore, the agreement between the actual readings and the calculations do not coincide. If the energy need for hot water was changed to the actual summer values, the calculations would agree better with the actual readings. The energy use for different kinds of energy is shown in Fig. 2 for the actual house as well as the calculated alternatives.

VIP+ is a more detailed software than ENORM thus also requiring some more input data. ENORM gives valid results for dwellings if the input data are plausible but any modelling of building physical aspects such as solar gains, thermal mass and air tightness is not possible.

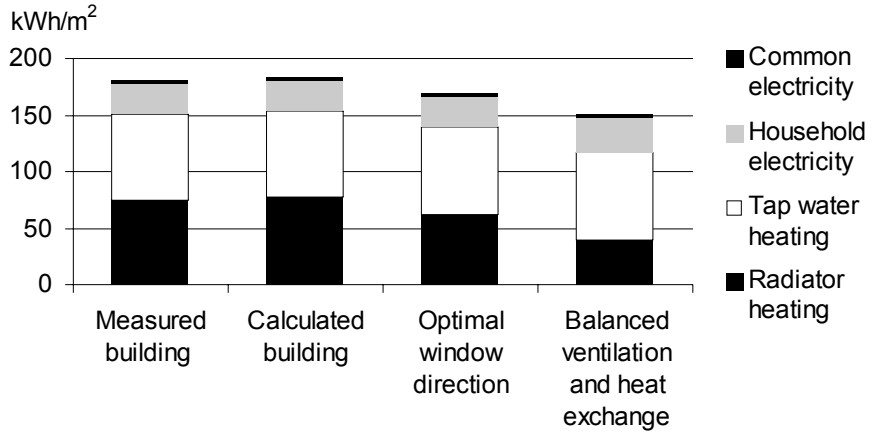

Figure 2 Total energy use 2001 for the examined building in Svedala. The tap water heating is estimated from the summer energy use for the actual measured building. The measured value of 2000 was used for household electricity as the value for 2001 could not be obtained.

3.5 Orientation of the building – solar gains – thermal capacity

The orientation of the windows of the original building is 80% to the North and 20% to the South. If the building is rotated 180º the required space heating is reduced by 13.4 kWh/m². The original building can be defined as a semi heavy structure with regard to active heat capacity. Parametric studies were conducted for also for a light and a heavy type of structure. With the original orientation of windows the annual difference between light and heavy structure is 2.8 kWh/m² and with the opposite orientation with more free excess energy from solar radiation the difference is 4.7 kWh/m² corresponding to 1.3 and 2.2 SEK/m², year.

Parametric studies on thermal mass, air tightness and orientation of windows indicate effects on annual energy cost of 1-6 SEK/m². These differences are rather small looking at the total annual costs but in the life cycle perspective they correspond to a present value of 30-170 SEK/m² and should thus be taken into account by the choice of design solutions.

4. CONCLUSIONS

The project in the case study in Svedala functions well except for the ventilation system that could have been a supply and extract system without increasing the life cycle cost. This would have benefited the energy use, the life cycle cost and the indoor thermal comfort. The problems with air quality and draught spotted in the questionnaire could have been solved by a supply and exhaust ventilation system. Maybe the indoor temperature could have been decreased with less heating need as a result. The air tightness of the building shell influences the energy use in buildings with balanced ventilation but not with mechanical exhaust ventilation. The building is tight compared to the regulations.

The building physics tools used in this study correlated well with each other and the simulation software indicated where there could be potential problems. A couple of measurements matched those of the calculated values, however most measured values fell a couple of degrees below the theoretical values. The tools also gave indications of areas that could be improved such as the ventilation air intake, and the effect of different ventilation systems on the life cycle cost however, the life cycle cost was not significantly reduced with a more complex system.

Burke
Kommentar: This is a limitation… where should we put it??

One problem with examining a house is the lack of models for user behaviour and a lack of measurements to split different energies and grounds for energy use. Measurements also need to be made with a smaller time interval.

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Environmental Assessment Tool for Buildings. Part.2 Evaluation of the Impact of Construction, Renovation and Demolition Process.

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1. INTRODUCTION

Buildings give impact to the environment during their service life. For example energy is consumed and carbon dioxide is generated in every stage of their lifetime such as producing building materials, manufacturing building components, transportation, construction on site, service through the service life, maintenance, renovation and demolition. An environmental assessment tool for buildings was developed by Kodama(1997) at the Building Research Institute in 1997 and was revised in 2001. The tool is a design tool that can predict the life cycle impact of the buildings in the early stage of designing procedures. And the tools was designed so that the users of the tool can find the environmental impact of each life stage of buildings and get the critical information of how to improve the original building design in order to reduce the impact.

A reliable database is quite necessary to predict the exact environmental impact of a certain building through out its service life. In Japan Ikaga(1999) and other researchers have reported the energy consumption and CO2 emission data for the building materials and components production and transportation. And same kinds of data are reported in many countries by many researchers. These data were collected either by the direct survey of the mills or the analysis of the input-output-table. We can have the overall data for energy consumption and CO2 emission by analyzing the input-output-table. But the detail

information is not available by this method. On the other hand we can have detail information from the direct survey of the mills. But it is almost impossible to get the whole embody energy data for all building materials and components by this direct survey.

To provide the database for the assessment tool a simple method to calculate the embodied energy and the embodied carbon dioxide of the building materials and components was developed. In this method the data derived from the analysis of the input-output-table and those derived from the direct survey of mills were combined to derive the data. The methodologies used in the tool in order to calculate the environmental impact of building materials production, building components manufacturing, transportation, construction on site, maintenance, renovation and demolition are presented in this paper. Data for other inventories such as NOx, SOx and ELU was also collected by analyzing the input-output-table data. The technical backgrounds of the calculation methods are reported in this paper.

2. LIFE CYCLE OF BUILDINGS

The life cycle of buildings are summarized in Figure 1. The life cycle of buildings start from the extraction of raw materials, followed by the production of building materials and components, construction and renovation of buildings and deconstruction or dismantlement of buildings. And some of the materials generated in the process of deconstruction or dismantlement are reuse or recycle and the rest of them are disposed. A certain amount of energy is consumed and a certain amount of CO2 is generated in all stages of the buildings' life cycle. In order to calculate the life cycle environmental impact of buildings the environmental impact data for all life stages should be provided.

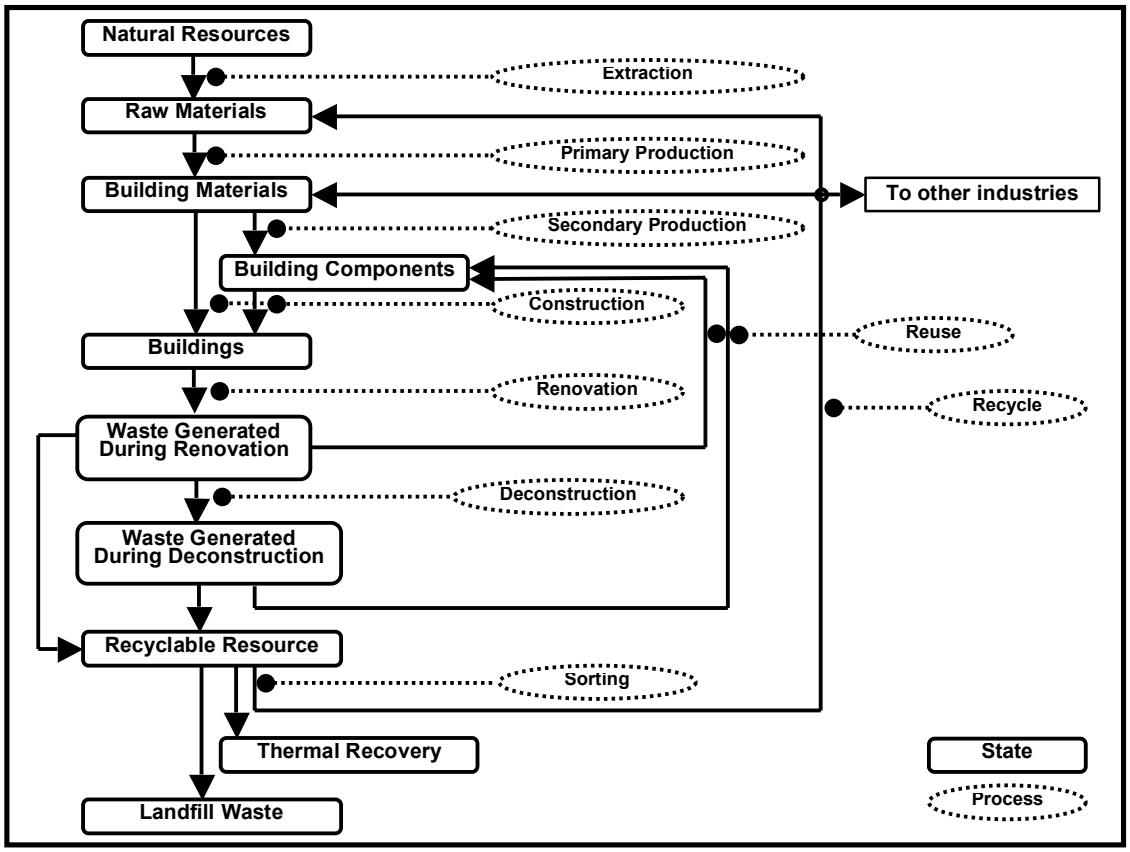

Figure 1 Life cycle model for buildings.

3. DATABASE OF THE EMBODIED ENERGY AND EMBODIED CO2

3.1 Embodied Energy and CO2 of Building Components

3.1.1 Calculation Method. The embodied energy and embodied CO2 data of building components were calculated using the results of the analysis of the 1995 input-output-table and the results of the direct survey of the mills. The embodied energy and embodied CO2 data for the primary production were calculated using the results of the analysis of the 1995 input-output-table and those for the secondary production were calculated using the results of the direct survey of the mills. And both data were combined to calculate the embodied energy and embodied CO2 data for the building components. The embodied energy and embodied CO2 values were calculated by Equation 1.

$$E = \sum_i (Q_{mi} \times E_{mi}) + \sum_j (Q_{ej} \times E_{ej}) \quad (1)$$

Where, E is the embodied energy or the embodied CO2 of building component,
Q_{mi} is the amount of the primary product i consumed in manufacturing process,
E_{mi} is the embodied energy or the embodied CO2 of the primary product i,
Q_{ej} is the amount of the energy source j consumed in manufacturing process and
E_{ej} is the embodied energy or the embodied CO2 of the energy source j.

3.1.2 Outline of the Survey. Questionnaire forms were mailed to 60 associations of the building components producing companies to receive information of the manufacturing process for 86 major building components. The following 4 items were questioned in the forms:

1) Type and amount of the raw materials consumed in the process of manufacture.
2) Type and amount of the energy source consumed in the process of manufacture.
3) Type and amount of the recycled materials consumed in the process of manufacture.
4) Service life of the building components.

3.1.3 Database. Information was available for 46 building components. For some building components the information was not enough to derive the accurate embodied energy and embodied CO2 data. For this reason the data obtained by the survey was not enough to represent all of the masses in a building. So the data from available literature were used for some items. Also for some other items temporally assumed data were used, which will be replaced when proper data are obtained. Table 1 shows the database of the embodied energy and embodied CO2 of the building components.

3.2 Energy Consumption and CO2 Emission due to Construction on Site

Six different construction systems, timber construction, light steel construction, heavy steel construction, reinforced concrete construction, steel reinforced concrete construction and concrete block construction can be chosen in the tool. As timber construction and reinforced concrete construction have several sub categories for their construction systems these sub categories are also included in the construction menu and are available for choice. The energy consumption data and the CO2 emission data for building assembly on site are installed in the tool as a table form database.

Table 1 Embodied energy and CO2 data for building components.

Categories	Building Components	Direct Energy Input and CO2 Emission per Unit			
		Energy Input	Unit	CO2 Emission	Unit
Temporary Construction	Tubular Scaffolding	1251	kJ/kg	0.424	kg-c/kg
	Steel Tube Post	1251	kJ/kg	0.424	kg-c/kg
	Steel Tube Beam	1251	kJ/kg	0.424	kg-c/kg
	Steel Base Plate	1251	kJ/kg	0.424	kg-c/kg
	Log Scaffolding	42308	kJ/m^3	9.673	kg-c/m^3
	Timber Scaffolding	42308	kJ/m^3	9.673	kg-c/m^3
Piling Work	PC Pile	111	kJ/kg	0.063	kg-c/kg
	PHC Pile	111	kJ/kg	0.063	kg-c/kg
	RC Pile	111	kJ/kg	0.063	kg-c/kg
	Timber Pile	42308	kJ/m^3	9.673	kg-c/m^3
Grading and Excavating	Shape Steel	1112	kJ/kg	0.393	kg-c/kg
	Steel Sheet Pile	1112	kJ/kg	0.393	kg-c/kg
	Light Gauge Steel Sheet Pile	1112	kJ/kg	0.393	kg-c/kg
	Log Pile	42308	kJ/m^3	9.673	kg-c/m^3
	Timber Sheet Pile	42308	kJ/m^3	9.673	kg-c/m^3
Form	Tie	2179	kJ/kg	0.771	kg-c/kg
	Aluminum forms	3571	kJ/kg	0.447	kg-c/kg
	Steel forms	1112	kJ/kg	0.393	kg-c/kg
	Wood forms	9474	kJ/sheet	1.090	kg-c/sheet
	Lath forms	319886	kJ/m^3	103.958	kg-c/m^3
Foundation	Cement	217	kJ/kg	0.214	kg-c/kg
	Sand	335	kJ/kg	0.118	kg-c/kg
	Gravel	335	kJ/kg	0.118	kg-c/kg
	Crushed Stone	335	kJ/kg	0.118	kg-c/kg
	Ready-mixed Concrete	75015	kJ/m^3	67.300	kg-c/m^3
Reinforcement	Reinforcing Bar (Plain)	834	kJ/kg	0.283	kg-c/kg
	Reinforcing Bar (Deformed)	834	kJ/kg	0.283	kg-c/kg
	Bolt	2179	kJ/kg	0.771	kg-c/kg
	Shape Steel	742	kJ/kg	0.262	kg-c/kg
	Light Gauge Shape Steel	742	kJ/kg	0.262	kg-c/kg
	Steel Pipe	1251	kJ/kg	0.424	kg-c/kg
	Steel Plate	1112	kJ/kg	0.393	kg-c/kg
	Steel Deck	1483	kJ/kg	0.524	kg-c/kg
Prefabricated Concrete	ALC	133137	kJ/m^3	63.496	kg-c/m^3
	Concrete Block (Type A)	152368	kJ/m^3	88.125	kg-c/m^3
	PC Plate	111	kJ/kg	0.063	kg-c/kg
	Brick	473	kJ/unit	0.143	kg-c/piece
Carpentry	Plywood	319886	kJ/m^3	103.958	kg-c/m^3
	Plywood for Structural Use	319886	kJ/m^3	103.958	kg-c/m^3
	Sawing Lumber	84616	kJ/m^3	19.346	kg-c/m^3
	Laminated Lumber	84616	kJ/m^3	19.346	kg-c/m^3
	Laminated Lumber (Fancy)	139059	kJ/m^3	32.697	kg-c/m^3
	Heavy Timber for Structural Use	84616	kJ/m^3	19.346	kg-c/m^3
Building Equipment	Water Boiler	11814	kJ/unit	2.640	kg-C/unit
	FF Heater	46301	kJ/unit	13.200	kg-C/unit
	Air Conditioner for Cooling	139260	kJ/unit	33.100	kg-C/unit
	Range Hood	43914	kJ/unit	10.540	kg-C/unit
	Ventilating Fan (Ceiling Type)	9117	kJ/unit	3.283	kg-C/unit
	Ventilating Fan (Wall Type)	1823	kJ/unit	0.657	kg-C/unit
	Hydrant	2179	kJ/kg	0.771	kg-C/kg
	Water Closet	3870	kJ/unit	1.111	kg-C/unit
	Wash Fountain	3870	kJ/unit	1.111	kg-C/unit
	Kitchen Equipment	166955	kJ/set	19.797	kg-C/set
	FRP Bath	1081718	kJ/unit	297.577	kg-C/unit

This database is composed of a series of standard energy consumption data and these data are provided for all construction types. In the case where prefabricate or industrialized building system is employed the standard energy consumption values can be reduced by multiplying a certain factor that represent the energy efficiency of the construction system. As the energy consumed in the process of construction depends on the building's elevation the modification factor to evaluate the elevation plan of the buildings are provided in the database. The energy that the workers consume on site and on their way to the site and home are also calculated and added to the standard energy consumption values. The energy consumed in the process of transporting building materials is also added to the standard energy consumption values. The standard energy consumption values and the multipliers for apartment houses are shown in Table 2.

Table 2 The standard energy consumption values and the multipliers for apartment houses.

Construction System			Energy Consumption per Floor Unit (MJ/m^2)		Multiplier	
Main Construction System	Sub Construction System	Construction Method	Construction (Apartment House)	Transportation of the Workers	Industrialized Factors	Factors for the Elevation of the Buildings
Wood	Post & Beam	Conventional	12.86	7.67	0.7(Panel)	1+0.15m
Wood	2X4	Conventional	12.86	7.67	0.7(Panel)	1+0.15m
Wood	2X4	Unit System	-	-	0.3(Unit)	1+0.15m
Wood	Wood Panel	-	9.00	7.67	0.7	1+0.15m
Wood	Heavy Timber	-	16.71	7.67	0.7	1+0.15m
Light Steel	-	Conventional	12.86	7.67	0.3(Unit)	1+0.15m
Steel	-	Bolted System	13.45	5.47	1.1(Welding)	1+0.053(3m+n-1)
RC	Rahmen	Cast-in-Place System	16.58	4.48	0.7(PC)	1+0.045(3m+n-1)
RC	Wall	Cast-in-Place System	16.56	4.48	0.7(PC)	1+0.045(3m+n-1)
SRC	-	-	17.59	6.01	0.7	1+0.095(3m+n-1)
CB	-	-	13.25	3.58	0.7	1+0.045(3m+n-1)

Note: The symbol m represent the number of basement floor and the symbol n represent the number of floors above the ground.

3.3 Energy Consumption and CO2 Emission due to Renovation and Renewal

The energy consumption and CO2 emission caused by renovation and renewal are automatically added in the process of calculating the lifecycle energy consumption and CO2 emission of the building. Every time the finishing materials end their service life the embodied energy of the replacing materials and the energy consumed in the process of transporting these materials to the construction site are automatically calculated and added to the life cycle energy of the building. So if the service life of a certain building is say 50 years and the service life of a certain interior wall is 20 years the finishing materials of the wall would be replaced for three times and every time the finishing materials are replaced the corresponding embodied energy would be added to the life cycle energy of the building. The structure of the database for finishing materials is designed so that this calculation process can be easily done in the tool. The database is shown in Table 3. The numerical values shown in Table 3 include the embodied energy of every finishing material consumed in the process of finishing $1m^2$ of floor, wall, roof or ceiling. The energy consumption caused by the workers' transportation is also added in order to derive the data for the database.

3.4 Energy Consumption and CO2 Emission due to Deconstruction and Demolition

For each building category above mentioned the energy consumption data for deconstruction and demolition and building waste processing are provided. The total energy consumption of deconstruction and demolition includes the energy consumed by the workers both on site and on the way to the site, operation of machines and transportation of the scrap. Reduction factors are provided to reduce the amount of the energy consumption according to the

demolition method. For example if the save-energy demolition method is applied the energy consumption can be reduced to 50% to 90%. And the effect of the number of the floors is also evaluated and a certain factor that represent the effect of the elevation of the buildings is multiplied to the energy consumption values. Table 4 shows the database for deconstruction and demolition. The database includes the energy consumption of machines' operation, labors' transportation and the multiplier that represent the effect of the number of the floors and the deconstruction or demolition methods.

Table 3 Database for the finishing materials.

No.	Finish Type	Sub Categories for Finish Type	Service Life (Years)	Total Energy Consumption/ Total CO2 Emission (per unit area)	
				Energy use (kJ/m^2)	CO2 emission ($kg\text{-}C/m^2$)
S1	Roof (waterproof finish)	Asphalt waterproof (1)	30	11649	8.125
S2	Roof (waterproof finish)	Asphalt waterproof (2)	15	4543	2.371
S3	Roof (waterproof finish)	Waterproofing sheet (1)	15	10659	7.817
S4	Roof (waterproof finish)	Waterproofing sheet (2)	15	3005	1.878
S5	Roof (waterproof finish)	Waterproofing mortal finish	15	2392	1.856
S6	Roof (waterproof finish)	Waterproofing coating file finish	10	2650	1.733
S7	Roof (metallic material finish)	Color metal sheet	15	19353	2.728
		(Table Continues)			
S135	Internal miscellaneous (unit)	Bath room	30	469	0.185
S136	Internal miscellaneous (unit)	Lavatory unit	30	469	0.185
S137	Internal miscellaneous (unit)	Stair	50	469	0.185
S138	Internal miscellaneous (unit)	Kitchen	30	469	0.185
S139	Internal miscellaneous (unit)	Toilet room	40	469	0.185

Table 4 Database for deconstruction and demolition.

Construction System		Energy Consumption		Multiplier for;	
Main Construction System	Sub Construction System	Machine Operation (MJ/m^2)	Workers' Transportation (MJ/m^2)	Number of Floors	Save Energy Method
Wood	Post & Beam	1.61	0.101	1	0.5-0.9
Wood	Wood Frame (2X4)	1.61	0.101	1	0.5-0.9
Wood	Panel	1.61	0.101	1	0.5-0.9
Wood	Heavy Timber	1.61	0.101	(9+n)/10	0.5-0.9
Light Steel	-	0.96	0.115	1	0.5-0.9
Steel	-	3.82	0.247	(9+n)/10	0.5-0.9
RC	Rahmen	5.49	0.148	(9+n)/10	0.5-0.9
RC	Wall	5.49	0.212	(9+n)/10	0.5-0.9
SRC	-	4.30	0.170	(9+n)/10	0.5-0.9
CB	-	5.49	0.212	(9+n)/10	0.5-0.9

Note: The symbol n represent the number of floors above the ground.

4. CONCLUSION

The database used in the tool is reported in this paper. Great effort is required to collect the whole data for building materials and components production, transportation, building construction, maintenance, renovation and deconstruction. And every two or three years every data should be revised to maintain its reliability. The database composes one of the most important part of the tool and BRI has launch into the task of revising the database.

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Environmental Assessment Tool for Buildings
Part 1. User friendliness of the Tool and Evaluation Logic for Environmental Impact in Building Use process

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1. Introduction

It has become more important to consider the environmental impacts of enormous human activities in the 21st century. One of our tasks today is to decrease the environmental impact of the activities related with construction and use of buildings as far as possible. For this purpose it is important to assess the building material consumption, transportation, energy efficiency of buildings and so throughout the lifetime of buildings, to construct comfortable buildings for living place and working office with less environmental impacts.

This is a report on the development of BEAT(Building Environment Assessment Tool), which began in 1991 and is still being evolved by the group oriented at Building Research Institute. BEAT is a life cycle assessment system working on personal computers, and calculates environmental impacts of many factors related with home housings and office buildings at the stages of producing building materials, manufacturing building components, carrying building materials, construction on site, use throughout the life time, renovation and demolition.

The purpose of BEAT development is to help designers of buildings to decrease environmental impacts especially in the beginning stage of design works. If the design works go with less consideration about environmental effects, it is very difficult to change them afterward. So, BEAT is designed as user friendly as possible, to be used by ordinary building designers who are not familiar with life cycle assessment and environmental effects of buildings.

In the beginning BEAT version 1.0 worked on Windows 3.1 in 1995 (Kodama 1997), and after continuing updates, now BEAT version 4.0 works on Windows 2000.(Sawachi 2001)
It included a life cycle estimate of energy consumption and carbon dioxide emission in the previous version. But now BEAT version 4.0 includes other environmental factors such as NOx, SOx, COD(Chemical Oxygen Demand), BOD(Biological Oxygen Demand),

SM(suspending materials), QM(quantity of materials related), and ELU(Environmental Loading Unit).

2. Scope and stages

BEAT treats the entire life cycle assessment of both the home housings and the office buildings. For life cycle assessment, the systems boundary is important. As it sometimes changes the results of calculation, we limited our life cycle analysis within boarder of Japan. This means, for example, BEAT excludes energy consumption and related environmental effects of aluminum smelting and production of fossil fuel energies as Japan import almost of them from foreign countries.

The life cycle of building is divided into five stages as follows.
1) Production and transport of building materials and components
2) Assembling on construction site
3) Using or living in the building
4) Renewal and renovation
5) Demolition

The environmental impacts are calculated from the database at each stage as shown in Tab.1.
BEAT covers the production and transport of main industrial materials such as steel, cement, glass, other metals and plastics, and the building components. When the materials and the components are produced, there are some input of energy and raw materials, causing some environmental impacts of NOx, SOx, SM, BOD, COD, QM and ELU. These impacts of production of materials and components are basically estimated by data of input–output analysis of industrial relation matrix, which is published by Japanese government periodically.
The impacts of building use are estimated by energy consumption such as electricity, oil and gas that are also connected with industrial relation matrix. The energy consumption of buildings is basically estimated by regression formula based on statistical data in Japan, and is modified by life style of habitants, insulation levels, solar hot water unit and PV.

Table 1 Calculation of Environmental Impacts at Each Stage

Stage	Calculation Methods of Environmental Impacts
Production of Materials and Components	Impacts of industrial relation table by specific weight or quantity of structure materials and component. Truck transport impacts by fuel economy and distance
Assembling on site	Specific Impact per floor area depending on assembling methods
Use of home housing	Regression model of energy demand for heating, cooling, hot water, cooking, lighting modified by life style, insulation level, solar heat and PV.
Use of office Building	Regression model of energy use for air conditioning, ventilation, lighting and other facility equipment.
Renewal and renovation	Impacts of producing finishing materials by industrial relation table periodically for 10-30 years
Demolition	Specific demolition machinery use per floor area depending on assembling methods. Truck transport of wastes to distant disposal site by fuel economy.

3. Structure of Computer Software of BEAT

BEAT has several branch windows for data input and calculation. User can select menu to the routines as follows,

1) Construction site and assembling method
User can select the construction site for the building from 839 areas in Japan with climate data of solar radiation and degree-days for demand of heating and cooling. Solar isolation is used to calculate heat supply of solar hot water unit and electricity of PV. Data of degree-days at the construction site are used to calculate energy demand of heating and cooling for independent houses and collective houses by each regression models. Also one can select assembling method and structure of building such as concrete base, steel and concrete, reinforced concrete, traditional wooden, two-by-four structure and others.

2) Materials and Components
User can input weight of structure materials such as concrete, steel, stone, sand and so. Also one can select various components in the database such as roofs, ceilings, finishing materials, insulation and so. User can selects the transport of materials and components using truck of which the mileage economies are listed for selection.

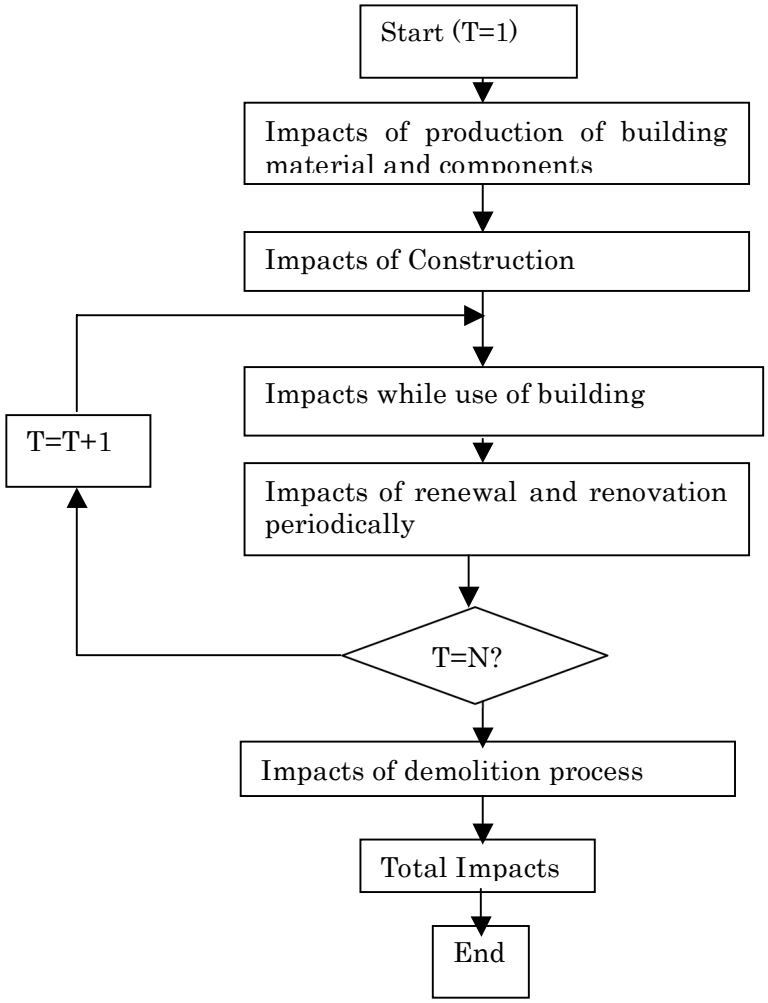


Figure.1 Flow Chart of BEAT

3) Life Style and insulation level for home housings
In case of home housings, user can input the number of family, the annual income,, the habits of energy consuming pattern for shower, bath and breakfast. Also user can select the insulation level of windows, walls, floors and ceiling.

4) Facilities of office building
In case of office buildings, user can select the utilities of buildings among varieties of facilities of heating, cooling, ventilation and lighting. Many advanced energy efficient equipments are prepared for user selection.

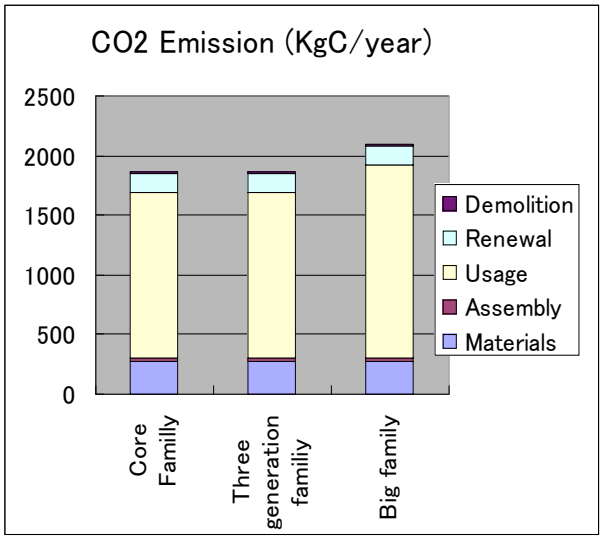
5) Demolition
User can input the distance between construction site and the disposal site for transport of waste materials, of which weight are automatically calculated separately for waste of wood, steel, aluminum, concrete and others depending on the construction methods and floor area. The demolition process is automatically calculated according to construction methods that determine the complexity of building structure.

6) Calculation
After input of the necessary data, the calculation of environmental effects are performed every year. If renewal and renovation is necessary, then the finishing materials are substituted and impact calculations are added. The results are shown in tables and graphs. User can compare the results of several cases using the stored result files.

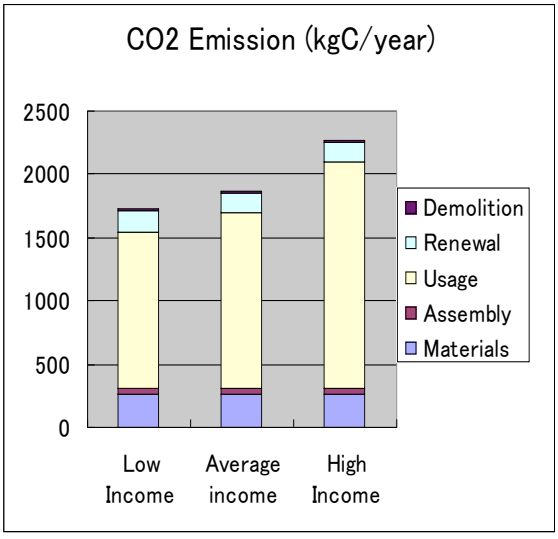
7) Database maintenance
If user wants to change the specific unit values of energy input, CO2 emission and other environmental effects from the materials or components, one can modify the database itself by this routine. Fig.1 shows the flow chart of BEAT in which year T is used as a loop counter until the end of lifetime(N year).

4. **Calculation Results**

BEAT calculates the environmental effects of energy, CO2, SOx, NOx, COD, BOD, SM, QM and ELU. Some of the calculated results are shown.

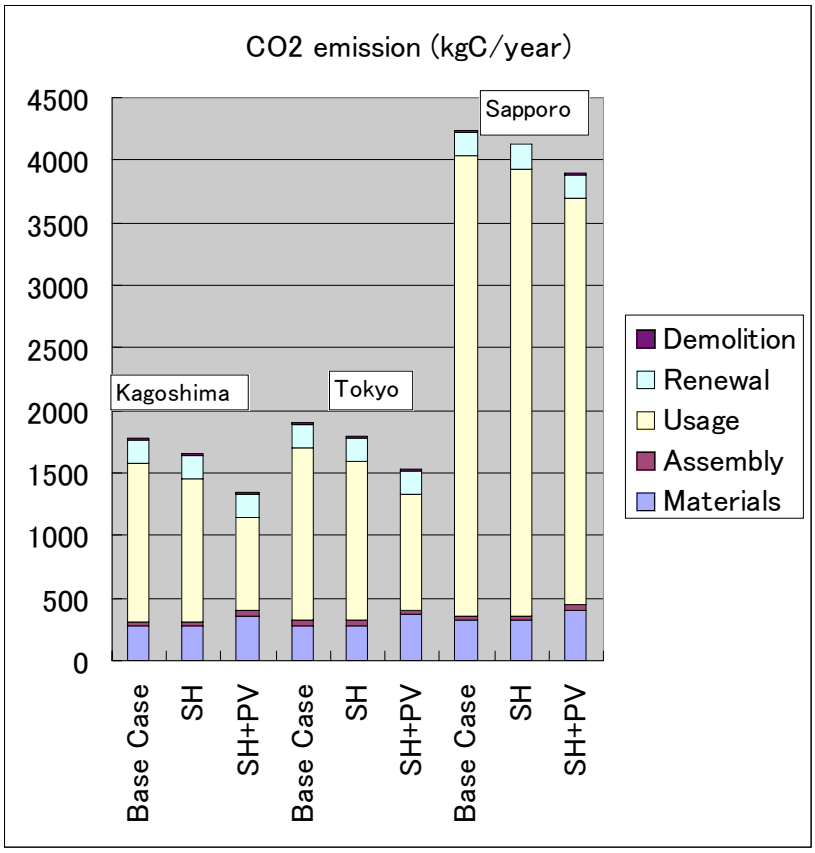


Figiure.2 Effects of habitant number



Figiure. 3 Effects of Income

Fig.2 shows the effects of number of habitants in the home housing. If the habitants are many, then CO2 emission increases. Fig.3 shows the effects of income of the family, which changes during the lifetime of the buildings, low in the beginning, increase while raising children, and decrease after retirement. Generally the energy use of household deeply depends on the income level, and the result shows the CO2 emission changes following income change. Fig.4 shows the base case of independent house without solar heater and PV, the house with solar heater, and the house with solar heater and PV in three sites, Sapporo, Tokyo and Kagoshima. Sapporo is located at Northern part of Japan and has big heating demand. The floor area of the house is 100 m^2. In the case of having solar heater and/or PV, the total CO2 emission decreases and the CO2 at use stage decreases while that of construction stage increases. Fig.5 shows the effects of length of building lifetime on the total CO2 emission. The graph shows the annual CO2 emission decreases when building is used longer by periodical renewal. Fig.6 shows the environmental impacts of energy, CO2 and other factors by relative intensity ratio for concrete reinforced three-story office building with floor area 1145 m^2. It shows that energy, CO2 and SOx are dominated in the use process of life cycle, while BOD is large in production of finishing material and QM is large in



production of structure materials.

Figure.4 Effects of Site(Kagoshima, Tokyo, Sapporo) and Solar heater+ PV

5. Conclusion

The development of BEAT is an effort to supply user-friendly comprehensive tool for the designers of home housings and office buildings. It is helpful for building designers to design buildings with less environmental impacts in the initial stage of design works. BEAT treats the environmental impacts such as energy, CO2, SOx, NOx, COD, BOD, SM, QM and

ELU. BEAT converts such numbers to the assessment of environmental impacts and shows the integrated impacts. The development work of BEAT is still continuing to update the database, to make models in the details, to improve the reliability, and to be user-friendlier.

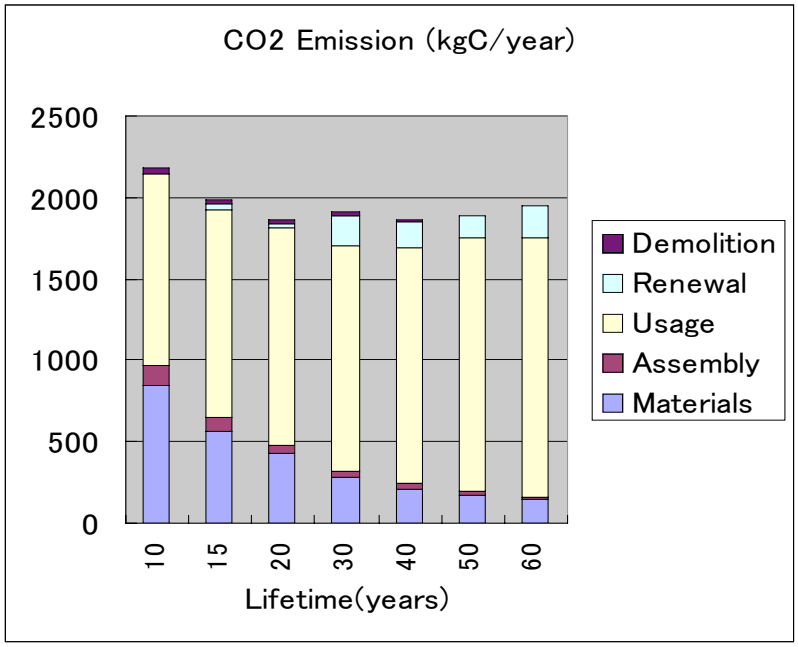


Fig.5 Effects of Lifetime and Renewal

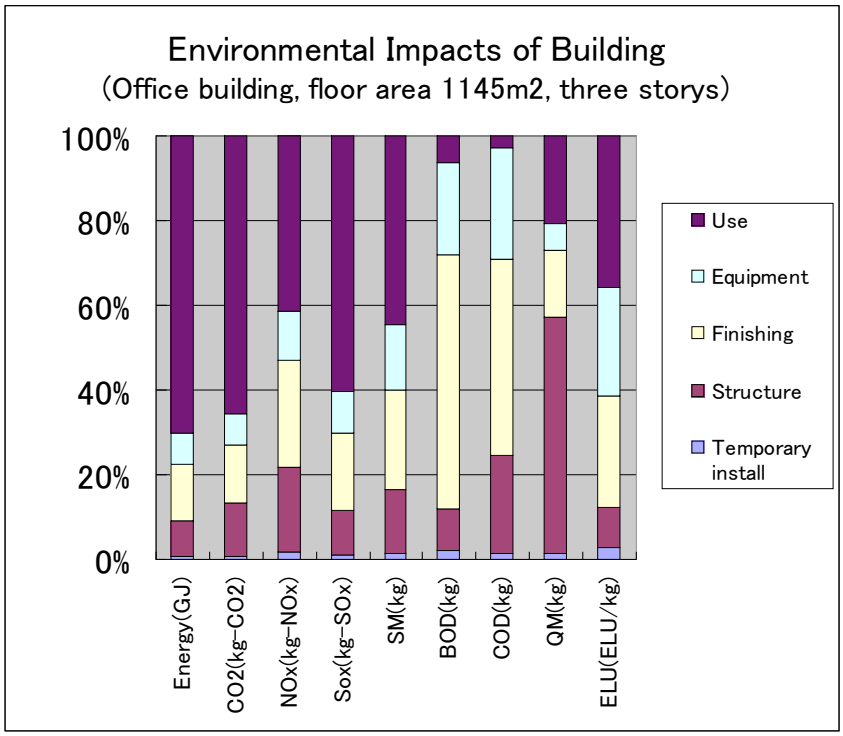


Figure 6. Environmental Impact of office building

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HQE : the French Green Building approach

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HQE is the acronym for “Haute Qualité Environnementale”, i.e. High Environmental Quality (of Buildings). The French « cultural exception » concerns not only culture products, like books and movies, but also Green Buildings, since the French building construction field doesn’t speak about “green buildings” or “sustainable buildings”, but about “HQE buildings”.[1]

WHERE DOES HQE COME FROM ?

In the seventies and the early 70s, “bio-climatic architecture” and renewable energies were promoted by a handful of pioneers, architects and engineers, supported by the French Ministry of Housing through calls for tenders like “H2E85” (Low Energy Housing for year 1985), while the oil high prices raised a legislation making a minimal thermal insulation of housing mandatory in 1974, reinforced and completed in 1982 and 1988.



[1] The term “green building” is considered in France as somewhat demagogic and too politically connoted. On the other hand, one considers that it is possible to speak about sustainable built environment (sustainability includes environmental, social, economic and gouvernance dimensions), but that we can only speak about the environmental quality of buildings.

Photo 1 : Warehouse “Les 3 Suisses” (Hem, 59) achieved in sept 96.
(photo Rémy Souchon, 3 Suisses)

During the early 90s, the lack of national volontary policy to maintain pressure for energy savings and to promote renewable energies use despite the breakdown of oil prices, joined to several counter-performant thermal solar plants due to optimistic theoretical yield calculation, sizing errors, lack of practice of handworkers, lack of maintenance, lack of training courses in architectural schools, made green building design to regress significantly, excepted a few brilliant private initiatives like the warehouse of the mail order selling company “Les 3 Suisses”.

During the late 90s, thanks to the recent success at the polls of the French ecologists allowing their participation into several local and regional executive assemblies, and into government (Ministry of the Environment), and to the growing concern of public opinion as well as industry and services managers for sustainable development, Green Buildings are meeting a real success again. The French Ministry of Housing launched in 1993 a 5 years expert working group, the ATEQUE (Atelier d’Evaluation de la Qualité Environnementale des bâtiments = Building Environmental Quality Assessment Workshop) and twelve “REX HQE” (HQE Experimental Realisations in social housing) totalising 584 dwellings, whose construction occurred between 1994 and 1998.

HQE : A GROWING SUCCESS, MAINLY FOR THE PUBLIC MARKET



Photo 2 : HQE High School Leonard de Vinci at Calais (achieved in sept 98,
1st French project presented at GBC2000). West facade : restaurant.
Photo Isabelle COLAS, architect, Calais.

This success appears mainly through public orders from regions like Nord-Pas-de-Calais, Ile-de-France, Alsace, Limousin, and more recently Rhône-Alpes, Champagne-Ardennes, Midi-Pyrénées, Provence-Alpes-Côte d'Azur and Centre for "HQE" secondary and high schools, regional headquarters or various public buildings construction or retrofit. Some public or semi-public housing builders recently started HQE collective housing construction, while several projects of HQE hospitals and clinics were initiated.



Photo 3 : HQE High School Leonard de Vinci at Calais. Internal street.
Photo Isabelle COLAS, architect, Calais.

THE HQE ASSOCIATION : A FRENCH SPECIFIC ANSWER TO THE DEMAND FOR GREEN BUILDINGS

The HQE Association (AHQE), a non-profit organization, has been created in 1996 by representatives of the main stakeholders of the building construction field (see the list of members table 1). Its broad representativity gives to AHQE a great legitimacy : its publications reflect the common will of the French construction field regarding the environmental quality of buildings and the sustainable development of the built environment, which gives to the French situation its specificity.

The members of the HQE Association

The market, suppliers, regulators and experts are fully represented. In July 2000, the AHQE had 38 members, active members (organisations), honor and associated members. Active members are the followings :

Market contracting bodies

Suppliers designers, control offices, construction firms, building products manufacturers, etc.

Regulators public authorities

Experts technical centers

Others associations promoting the development and the practice of the HQE approach

Market (contracting bodies) :

- ARENE Ile-de-France *(Agence Régionale de l'Environnement et des Nouvelles Energies)*, Environment and new energy agency for the Ile-de-France region
- Conseil Général du Bas Rhin, general council of the Bas Rhin region
- Conseil Général de l'Hérault, general council of the Hérault region
- Conseil Régional d'AIsace, regional council of Alsace
- Conseil Régional d'Aquitaine, regional council of Aquitaine
- Conseil Régional du Centre, regional council of Centre
- Conseil Régional de Champagne-Ardenne, regional council of Champagne-Ardenne
- Conseil Régional de Haute-Normandie, regional council of Haute-Normandie
- Conseil Régional du Limousin, regional council of Limousin
- Conseil Régional du Nord-Pas-de Calais, regional council of Nord-Pas-de-Calais
- Conseil Régional de Poitou-Charentes, regional council of Poitou-Charentes
- Conseil Régional de Rhône-Alpes, regional council of Rhône-Alpes
- UNHLM - DMOP *(Union Nationale des HLM - Direction de la Maîtrise d'ouvrage et du Patrimoine)* National Union of Low Cost Housing Organisations
-

Suppliers (designers, control offices, construction firms, building products manufacturers, etc.)

- AIMCC *(Association des industries de Produits de Construction)* construction products industry association
- CAPEB *(Confédération de l'Artisanat et des Petites Entreprises du Bâtiment)* confederation of building industry artisans and SMEs
- CICF *(Chambre des Ingénieurs-Conseils de France)*, French consultants-engineers Chamber
- CNDB *(Comité National pour le Développement du Bois)*, National Committee for the promotion of Wood usage
- COPREC Construction *(Comité professionnel de la prévention et du contrôle technique dans la construction)*, Professional Committee of prevention & technical control in the construction sector
- CROAIF *(Conseil Régional de l'Ordre des Architectes d'Ile-de-France)*, Ile-de-France Regional Council of Architects
- FFB/DAT *(Fédération Française du Bâtiment - Direction* des *Affaires Techniques* French building federation, technical affairs office
- FILMM *(Syndicat national des Fabricants d'Isolants en Laines Minérales Manufacturées)*, French syndicate of producers of manufactured mineral wool insulation
- ICEB *(Institut des Conseillers Environnement pour le Bâtiment)*, environmental advisories institute for the building industry
- SER *(Syndicat des Energies Renouvelables)*, Union of Renewable Energies
- UNSFA *(Union Nationale des Syndicats Français d'Architectes)* National Federation of the French Architects Union
- UNTEC *(Union Nationale des Economistes de la Construction et des Coordonnateurs)*

French union of construction economists and coordinators
- UBP *(Union des syndicats de la Plasturgie BTP)* union of French plastics technology syndicates for the building and public works industry
-

Regulators (public authorities) :
- MATE – D4E *(Ministère de l'Aménagement du Territoire* et de *l'Environnement - Direction des Etudes Economiques et des Evaluations Environnementales)* French ministry of territorial planning and the environment. Economical studies and environmental assessment office
- MCC/DAPA *(Ministère de la Culture et de la Communication / Direction de l'Architecture et du Patrimoine)*, Ministry of culture & communication / Direction of architecture & heritage
- METL - DGUHC *(Ministère de l'Equipement des Transports et du Logement -Direction générale de l'Urbanisme de l'Habitat et de la Construction)*, French ministry of equipment, transport and housing, office of urban housing and construction
- MIES *(Mission Interministérielle de l'Effet de Serre)* Inter-ministry mission for greenhouse effect
- MIQCP *(Mission Interministérielle pour la Qualité des Constructions Publiques)* Inter-ministry mission for the quality of the public constructions
- PUCA *(Plan Urbanisme Construction Architecture)*, urban construction and architecture plan
-

Experts (technical centers) :
- ADEME *(Agence de l'Environnement et de la Maîtrise de l'Energie)* the French environment and energy agency
- CERIB *(Centre d'Etudes et de Recherches de l'Industrie du Béton)* Study & research center of the precast concrete industry
- CSTB *(Centre Scientifique* et *Technique du Bâtiment),* French building research establishment
- CTBA *(Centre Technique du Bois et de l'Ameublement)* Technical center of wood and furniture
- CTTB *(Centre Technique des Tuiles et Briques),* French tile and brick research establishment
- Association Qualitel
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Others (associations promoting the development and the practice of the HQE approach) :
- ABAQUE Réunion *(Association pour le bâtiment et la Qualité Environnementale à la Réunion)* Association of department of Réunion for the Building and the Environmental Quality
- AJENA *(Association Jurassienne pour la diffusion des Energies Alternatives)* Association of department of Jura for diffusion of alternate energies
- ARCHINOV *(Association* des *architectes et* de *leurs partenaires pour développer l'innovation)* association of architects and their partners for developing innovation
- Association Alsace Qualité Environnement environmental quality association of Alsace
- Comité 21, Committee for the 21th century
- Ecopôle : *Maison de l'Environnement,* House of Environment, Nantes
- FFNE *(Fonds Français pour la Nature et l'Environnement)*, French Fund for Nature & Environment

THE ACTIONS OF THE HQE ASSOCIATION

Through the active work of its members, the HQE Association is developing several actions :

- to elaborate reference texts to provide ground rules
- to produce thematic report, such as ***buildings and health,***
- to participate in international debates concerning sustainable development themes,
- to participate in and to encourage sustainable building operations,
- to publish and co-publish documents,
- to create regional resource centers, testing labs and information offices for sustainable building operations,
- to host and participate in information [2] and training operations,
- to answer questions from professionals and the general public.
-

WHAT IS THE ENVIRONMENTAL QUALITY OF A BUILDING (FORMAL DEFINITION) ?

The environmental quality of a building corresponds to the characteristics of the building, of its facilities (products & services) and of the rest of the plot of the construction or retrofit of the building, which give to it the ability to fulfill the needs for mastering its impacts on the outdoor environment and for creating a comfortable and healthy indoor environment.

HOW TO IMPROVE THE ENVIRONMENTAL QUALITY OF A BUILDING ?

Persistent efforts must be made for upstream.

Realizing the environmental quality of buildings and taking part in the sustainable development of the built environment :

- **Eco-IocaIising**, to safeguard the best possible relationship between the site and the use of the building.
- **Eco-planning**, to define specifications integrating the 14 targeted process methods listed below into demands adapted to the operation and its budget.
- **Eco-designing**, to arrange and configure the building, to select the construction techniques (i.e. construction processes, systems and products) that adhere to the environmental demands in the specifications;
- **Eco-realizing**, to organize a Iow nuisance construction site;
- **Eco-managing**, to operate the building in a way that ensures a satisfactory sustainability of its environmental characteristics.

Adopting the following environmental management principle for each of these phases :

- To encourage a concerted approach among all parties as early as possible;
- To check that environmental concerns are addressed by the right people at the right time;
- To adapt technical solutions to the specifics of the operation.

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[2] The HQE Association has coordinated the French participation to Sustainable Building 2000, an international meeting held in Maastricht (NL) in october 2000.

14 TARGETS FOR ACHIEVING THE ENVIRONMENTAL QUALITY OF BUILDINGS

Mastering the environmental impact on building exteriors

ECO-CONSTRUCTlON
1. Harmonious relationship between the buildings and their immediate environment
2. Integrated choices of construction processes and materials
3. Low nuisance construction sites

ECO-MANAGEMENT
4. Energy management
5. Water management
6. Waste management
7. Repair and maintenance management

Creating a satisfactory indoor environment

COMFORT
8. Hygrothermic comfort
9. Acoustic comfort
10. Visual comfort
11. Olfactory comfort

HEALTH
12. Sanitary conditions of indoor spaces
13. Air sanitary quality
14. Water sanitary quality

IS « HQE » A TRADE MARK ? A STANDARD ? A BUILDING OR DESIGNER OR PRODUCT LABEL ? A CERTIFICATION SYSTEM ?

The sigle « HQE » is neither a standard, nor a building label, but a future environmental management certification of construction operations

The acronym « HQE » has been protected by AHQE as a trade mark in order to prevent its misuse.

The objective of the HQE Association is to build up a certification process based on the reference text for the environmental management of building construction or retrofit operations. This reference text is derived from the ISO 1400x reference standard for the environmental management of product manufacturing or service supply.

It is not wished that the HQE becomes a standard because of its great complexity and of the lack of knowledge about the environmental impacts of buildings. Conversely, the reference text on the environmental management system can become a standard since it describes mainly administrative procedures and will be adapted from ISO 1400x [3].

The “HQE approach” is and should remain a not compulsory, but volontary commitment, taken by the contracting authority.

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[3] Adaptation is needed to fit the specificity of a building construction or retrofit operation : many stakeholders, limited-life activity.

Regarding stakeholders, there is no "HQE" architect or engineer, but people having followed training courses on the HQE approach validated by the HQE Association.

Regarding products, there is no "HQE" product, but a new French AFNOR standard helps manufacturers to give information on the environmental quality of their products and on their contribution to the environmental quality of the buildings where they are used.

WILL "HQE" RAISE A NEW JOB ?

It is not desirable that the HQE approach will be trusted by new specialists. Conversely, each stakeholder has to take part to the global HQE approach at its level. However, on can forecast that HQE advisors will remain necessary for several years to help contracting bodies to write down the specific environmental technical specifications for HQE operations and to build up the environmental management system and to supervise its use.

WHAT ARE THE NEXT MAIN ACTIONS TO BE DONE ?

The next prioritary actions of the HQE Association are :

- to finalize the environmental management reference text,
- waiting for that achievement :
  - to elaborate an assessment method for existing self-claimed « HQE buildings operations » in order to check the validity of their claim,
  - to define recommendations to the contracting bodies wishing to start an HQE approach,
- to validate the existing training courses introducing to the « HQE approach » and to elaborate the ones necessary for specific stakeholders (e.g. contracting bodies)
- to elaborate the "explicit definition of the HQE", i.e. the quantitative requirement levels for each parameter defining the quality for each target, depending of the type of operation (construction or retrofit), of building (housing, office, shool, etc.), of climate, etc.
- to follow and if possible to participate to the work of ISO/TC59/SC3 "Functional/user requirements & performance in building construction" , especially regarding the 2001 program related to sustainable buildings [4].
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CONCLUSION

The confrontation of the original approach of green buildings adopted by the French construction stakeholders with those used in other countries can lead to fruitful comparisons, regarding the concerted participation of all concerned parties as well as the way the environmental quality of buildings is defined and coupled with an environmental management system of building construction operation. We hope that this paper will inspire some foreign colleagues to undertake such comparisons and to take the French experience of green buildings construction into account while elaborating new international reference documents.

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[4] N422 : Terminology related to sustainability, N446 & N448 : Assessment of impact from & environmental declaration of building products, N450 : sustainability indicators

Eco-efficient Building Process

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1. INTRODUCTION

1.1 Sustainability indicators

The principles and requirements of sustainable development define the ecological, economic, social and cultural boundary conditions for the activities of societies, enterprises as well as of individual citizens. The construction industry and the built environment must be counted as two of the key areas if we are to attain a sustainable development in our societies as stated in CIB Agenda 21 on sustainable construction (CIB 1999). The progress of sustainable building requires the development of sustainability concepts, which help us in stating goals as well as in following-up the results.

The development of the generic conceptual framework for sustainable development has essentially taken place in terms of sustainability indicators. Results have been worked out for example by CSD (The Commission on Sustainable Development), OECD (1998) and EEA (1999). Sustainability indicators are developed both in order to aid target setting and to enable comparison of end-products and monitoring the progress. Also the building sector develops sustainability indicators in order to assess the quality of built environment, buildings and products. The European thematic network CRISP (Construction and city related sustainability indicators) collects and summarises sustainability indicators of buildings and built environment (CRISP 2002).

In addition to sustainability indicators that help us to describe and rate end-products, we would also benefit from the sustainability indicators of the process. These should help us to develop the roles and necessary knowledge and facilities of actors. These should also help us to identify the weaknesses in information management and transfer of information from the point of view of sustainable building and its requirements.

1.2 Eco-efficiency of products, services and activities

The eco-efficiency concepts also deals with the sustainable development aspects with help of indicators. We define the eco-efficiency concept to differ from the sustainable development concept in two main features as follows.

- Eco-efficiency concepts has a narrower point of view concentrating on ecological and some times also economic aspects and paying less attention to direct social and cultural aspects.
- Eco-efficiency concept always makes use of input-output approach.

World Business Council for Sustainable Development (WBCSD) first introduced the concept of eco-efficiency in its report for the UN conference on sustainable development in 1992. The meaning of eco-efficiency concept has been widely discussed ever since. The OECD (1998) has defined the term in such a way that "Eco-efficiency expresses the efficiency with which ecological resources are used to meet human needs". According to the OECD report, eco-efficiency can also be defined as a ratio of output and input so that the output represents the value of the products or services that a company produces and the input is the sum of environmental pressures caused by the production.

$$\text{Eco-efficiency} = \frac{\text{Value of products or services}}{\text{Environmental pressures}}$$

VTT's research project REKOS (Häkkinen et al. 2002) has applied the above mentioned eco-efficiency formula on buildings by relating the performance and conformity of a building with its environmental pressures:

> *The eco-efficiency of a building is defined as the ratio of the building performance and conformity to the environmental pressures induced by the technical solution that fulfil the client's requirements. These requirements cover both the performance of the building and its conformity in terms of location, spaces and services.*

$$\text{Building Eco-efficiency} = \frac{\text{Performance and Conformity}}{\text{Environmental pressures}}$$

The building eco-efficiency is studied with help of output - input approach. The output is dealt with on the basis of building performance and conformity while the input is dealt with on basis of environmental pressures. Correspondingly, we can study the cost-efficiency of a building having the whole-life costs in the denominator. The parameters of performance, conformity and environmental pressures are outlined as shown in Figure 1.

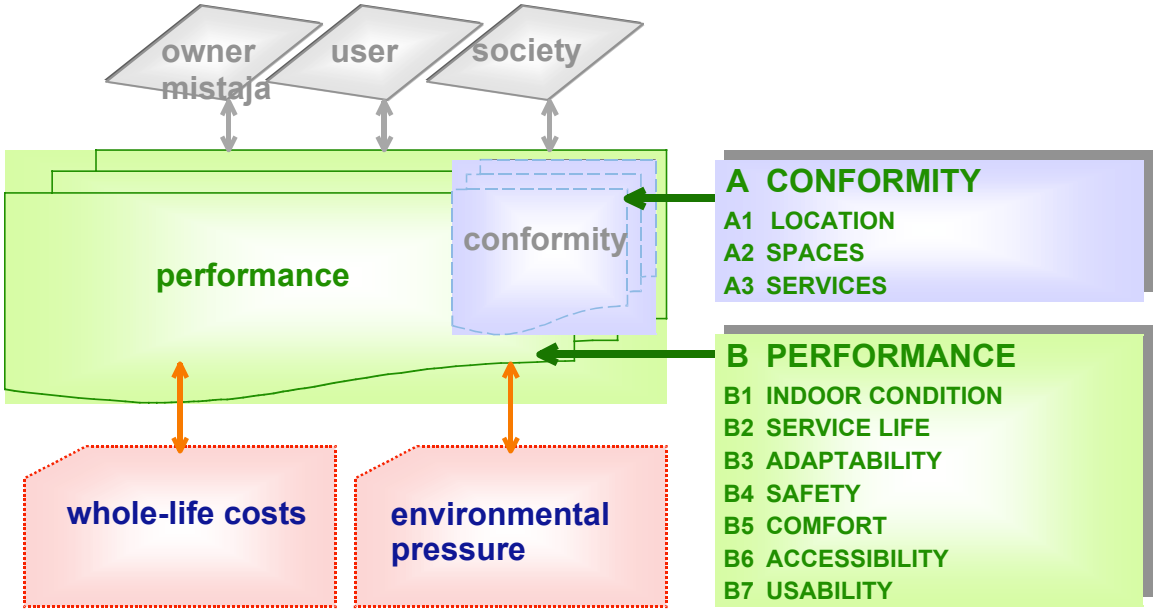

Figure 1. VTTProP Systematics on Building Headings (main level).

Consistently, Eco-efficient Construction was defined to bring about the required performance of a building with the least unfavourable ecological and economic impact.

More widely, Sustainable Construction was defined to bring about the required performance with the least unfavourable or the most favourable ecological, economic as well as social and cultural impact at both in a local and regional as well as at a global level.

2. SCOPE

The eco-efficiency of building process was studied with reference to the defined eco-efficiency of end-products. The focus was to identify and specify the essential requirements of the process with reference to

- the roles of different actors,
- the necessary knowledge and facilities of different actors,
- the information management and transfer of information between different actors especially with regard to requirement management and product specific information.

3. ACTORS OF BUILDING SECTOR

The actors of building sector were dealt with on the basis of the following out-lining: Owners, Users, Building managers, Developers, Contractors, Designers and Manufacturers.

In addition to the listed actors, the process includes public bodies, research organisations and other organisations that administer, guide, help or represent the building process actors without directly being involved in the actual building process.

4. ECO-EFFICIENCY OF DIFFERENT ACTORS OF BUILDING PROCESS

The following Table describes the main role of different actors in the eco-efficient building process.

Table 1 Main role of different actors in the eco-efficient building process.

	Owners
1	To recognize and take into account the environmental aspects of lot location when purchasing new real estate
2	To set appropriate requirements on conformity, performance and environmental impact when investing in real estate
3	To set requirements on the knowledge and facilities of consultants and building managers with regard to performance, service life and environmental impacts of buildings
	Users
1	To set appropriate requirements on conformity, performance and environmental impact when renting facilities or dwellings
2	To set requirements on the knowledge and facilities of consultants and building managers with regard to performance, service life and environmental impacts of buildings
3	To recognize and follow the set guidelines concerning the maintenance of buildings.
	Building managers
1	To recognize the eco-efficiency requirements set by the owner and the user
2	To interpret the requirements concerning indoor conditions as practical guidelines of the building management
3	To carry out eco-efficient building management by: - determining and following-up indoor conditions and energy, water and waste flows - finding out the reasons for anomalies and variances and managing the flows and conditions - looking for improvements and savings, making suggestions for owners and users and carrying out corresponding measures - recognizing and following-up the maintenance manual.

	Developers
1	Knowledge on building requirement management. The use and management of corresponding tools.
2	To recognize the eco-efficiency requirements set by the client. To support the client's requirement-setting
3	To take care that the requirements set by the owner are fulfilled within building. Verification management. The use of tools that aid verification.
	Designers
1	To recognize and follow the eco-efficiency requirements set by the client. To support the client in setting eco-efficiency-related requirements.
2	To manage performance approach, service-life and life-cycle design and energy-efficient design methods, to apply relevant tools and data basis,
3	To interpret the conformity, performance and environmental requirements and to produce consistent design solutions with regard to position, spaces, structures, building services (HVAC) and finishing materials.
4	To work out a maintenance manual providing the use phase of the building with approriate and adequate information about the life cycle of the building products including building services. These instructions should support eco-efficient use and management of the building.
	Contractors
1	To hear the eco-efficiency requirements set by the client so that these requirements form the basis for the construction
2	To carry out the construction process according to the design and the set eco-efficiency requirements with help of the contractor's own quality management and environmental management systems. These should assure the conformity of the end-product with set requirements also in the case of defective design. The systems should cover the selection of other partners. The contractor should be able to manage the whole process being able to suggest alternative eco-efficient solutions, if those are not considered earlier.
3	To make use of product information assuring that the product-specific requirements with regard to building are taken into account. To assure the 'lifecycle' of product-specific information so that this information is transferred to the users and building managers to be taken into account within building maintenance and repair..
4	To be able to show the consistence of the building solution with the set eco-efficiency requirements when necessary..

	Manufacturers
1	To identify and improve the environmental impact induced from the manufacturing process. This should happen with help of life-cycle assessment, developing the process, target-setting and following-up.
2	To identify and improve the performance and service life behavior of the products. This should happen with help of testing and developing, service life prediction, idenfying the affecting parameters, target-setting and following-up.
3	To work out environmental and service life information about the products and to provide the designers, contractors and users with this information. The environmental and service life information should aid the eco-efficient use of the products.

5. CONCLUDING REMARKS

The eco-efficiency of building process depends essentially on the following issues:

1) Setting of requirements. The setting of requirements can be seen as the premise for eco-efficient building process. A true eco-efficient process has to be based on the awareness of clients and voluntarily set requirements although the process can also be normatively guided by public bodies.
2) Out-lining of requirements. Although the choice and level of requirements has to be based on the client's needs, the framework of requirements should be commonly agreed upon. This is important to assure a solid basis for continual development of the process and end-products.
3) Transfer of information. The process should assure the unbroken and easy transfer of all needed information. This includes the transfer of requirement-related information throughout the process. On the other side, the product-specific (performance, service life and environmental) information should meet the building design and form the building-specific data basis aiding eco-efficient building maintenance. Eco-efficient building process needs life-cycle information and it has to assure the life-cycle of information. These challenges can only be met with help of IC-technology aiding the easy transfer and storage of information.
4) Development of verification methods. The setting of eco-efficiency requirements is useful only when we are able to verify the consistence of the design and the end-product with the set requirements. This demands commonly agreed methods of assessment and simulation.

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The scale of Autarky; self sufficiency through integrated design of decentralised natural technologies in citydistricts and buildingclusters

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1. INTRODUCTION

1.1 Optimum scale self-sufficiency

To find the true sustainable form of self-sufficiency, viz. autarky, it is important to optimise the scale factor. Other factors to be taken into consideration are the suitability within a socially acceptable form and the cost factor in relation to efficiency. It is important to realise that in the standard practice of urban planning, space for water clearance, energy production and waste treatment is mostly found outside the city, while broadening the bio-diversity and food production are sometimes even found in other countries. This results in the necessity of transporting energy, water and waste to centralised treatment plants outside cities and consequently an enormous amount of technical infrastructure. If the optimum scale for each one of the flows could be found, considerable cost reductions would arise from technical infrastructure which is no longer required, and generating funds for investment in ecological solutions would intensify. The optimum would be self-sufficiency, or autarky. However, autarky cannot be found on one fixed scale. The optimum scale or scales for autarky should be found between a centralised level and an individual level with a visible differentiation of the various flows - water, energy and waste or materials [fig. 2]. Therefore the manner in which these different optimum scales are combined will be decisive for a true sustainability of urban planning.

Most of the existing urban infrastructure can be typified as an 'end of pipe' planning strategy. We transport waste, wastewater and even relatively clean rainwater outside urban districts to centralised treatment plants. We attempt to generate electricity or gas in centralised gas plants, sometimes with an energy-efficiency factor below 10%. The upshot of this is much more than the transport requirement and the use of extra material and energy. The inevitable mixing of

different elements is detrimental to the quality. The majority of the transported flows undergo losses during transportation which also has serious impacts on the immediate environment.
The way to permanent urban development appears to be elusive. In modern town planning new inventions and the introduction of intelligent light infrastructure are required. In the long term only closed cycles for processes and use of material could result in a permanent urban environment. The scale of these closed cycles should be located as close to the users as possible. Furthermore, the system should be based on passive and natural technologies.

1.2 Flows, areas and participants

The 'Ecopolis strategy' (Tjallingii, 1996) is a new form of urban planning which may assist in lowering the environmental pressure. This strategy differs from traditional planning in the Netherlands where urban planning is normally one-dimensional. Instead of only assigning functions to locations, the Ecopolis strategy attempts to incorporate the different flows (water, energy, waste) and transport as key factors in ecologically sound planning. Another aspect of this strategy is that both the participants and the spatial quality of areas play an important role in the process of sustainable urban planning. Therefore, the Ecopolis strategy focuses on these three basic elements for urban planning: flows, areas and participants [fig. 1].

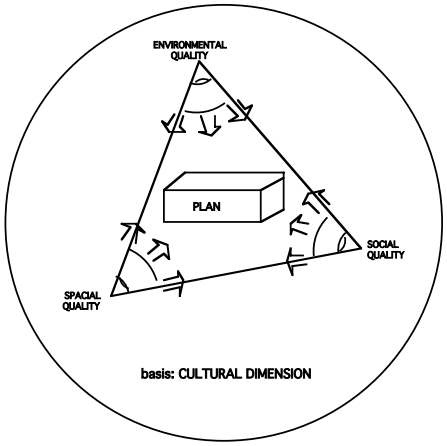

Figure 1 points of view in Urban Planning

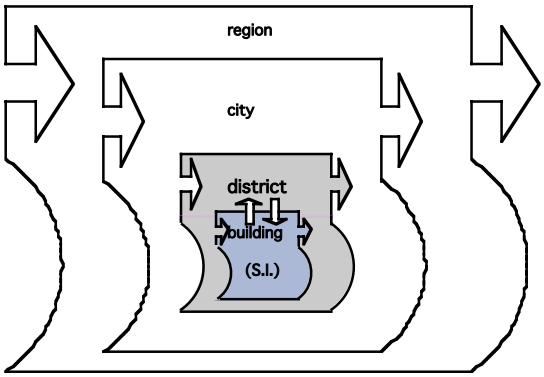

Figure 2 implementation scale closed cycles

One of the key issues in achieving sustainable urban planning is to consider an issue from the viewpoint of flows. Each country, city, neighbourhood or building can be seen as a 'system' with incoming and outgoing flows of energy, water and material/waste. The advantage of flows is the opportunity to quantify them. The effects of a specific, chosen solution can be clearly visualised.

It is essential to separate the various components, and therefore different qualities in flows, and also to optimise or minimise the quantities. Mixing its qualities is unsustainable, exergy principles should be the basis of every solution.

The 'area' angle is also important when dealing with an issue. Areas have ecological and spatial qualities. The liveability of an area is significantly dependent on its ecological quality. The utilisation functions and the impacts of solutions for liveability, sanitary aspects and the quality of life are decisive for ecologically sound urban planning. The special qualities of an area form a crucial factor in its liveability and could therefore be improved by combining cultural and natural use of such areas. Optimum use could be achieved by varying higher and lower densities in relation to the optimum scale for self-sufficiency. Multifunctional use

(living, working, recreation) will also contribute to the creation of ecological conditions. The links between different areas should always be of an ecological nature.

Finally the 'participants' angle - that of the users, the legislators and the suppliers of the different flows for which forms of autarky are being claimed - have a significant impact on the environmental pressure of urban space. Increasing their awareness of the effects of their actions on the surrounding environment should be the main goal. Organising forums is a good way of doing this, as in the case of Lanxmeer, illustrated later, where participants work together towards the integral quality of the plan while at the same time increasing their own awareness. Personal involvement of 'users and originators' could also be improved by making the flows more evident. Another possibility is bringing sustainable solutions closer to the users via decentralisation. All these actions allow users to directly become aware of the positive and negative impacts of their behaviour. In this situation special attention should be given to guaranteed sanitation and good long-term management. By bringing sustainable solutions closer to the users, the costs of technical infrastructure can be reduced and can be invested in ecological qualities and sustainable or natural technologies.

2. FROM FLOWS TO CIRCLES

2.1 Creating space in cities

A lot of strategies that aim to achieve environmental improvement of the existing flows, primarily begin by attempting to optimise the energy, water and material demands. Normally they attempt to do so by quite simply making, or forcing, the users to behave in a more conscious manner, through advertising or price increases. One could say that these strategies for attempting to realise more economical behaviour are like swimming upstream. One unresolved issue remains: many people have a natural tendency to compare and therefore desire increasingly larger areas of space, more comfort and more luxury. Therefore they will consume more in every respect. This increase in consumption can only be restricted with great difficulty, with expensive and often repressive government campaigns. The central issue in sustainable planning is how will it be possible to create sufficient space in cities for forms of natural technologies and new decentralised concepts in order to fulfil the (increasing) demand for consumption, without increasing the pressure on the environment.

2.2 Increasing the environmental productivity

An important goal in sustainable planning has to be the creation of a balance between the pressure on the environment and the bearing capacity of the available space in the area concerned. The country, city, district or building in question could be considered a closed eco-device with incoming and outgoing flows that should be in equilibrium [fig. 2].

The question is whether each of these flows should be transformed into cycles within the same 'scale'. It is important to consider the existence of a certain scale-paradox (De Jong, 1996). Taking the existing level of comfort as a starting point, this may first of all mean the previously stated necessity of piling up functions or solutions in the respective area, and secondly the return to an optimum scale of autarky per flow. The integration of solutions for the different flows, combined with the attempt o reduce the required ground surface and therefore the production of extra 'environmental space', is the subject of this study. Emphasis will be placed on the solution and integration of water treatment, energy generation and re-use of waste. The food production, increasing bio-diversity and traffic reduction will be dealt with in a more general manner. An attempt will be made to find the suitable optimum scale or scales on which a tool, called Sustainable Implant (S.I.) can be implemented in order to

achieve the previously stated reduction with a factor of 20 of the environmental load. Another possibility is increasing the environmental productiveness by reducing the surface and technical infrastructure required for making the urban surroundings more sustainable. In the latter situation you could imagine that there is a physical purpose for this kind of increase in environmental productiveness. Water treatment, sustainable energy production and food production are based on processes that are dependent on natural light. Key factors in finding the optimum will therefore be related to the optimum use of sunlight per square metre using as little composite materials as possible. Combined use of sunlight (and warmth) for different treatments (water, energy, and waste) may lead to sustainable solutions.

2.3 Natural technology in water and wastewater treatment

Ecological design principles, in which nature's wisdom is incorporated into the designs, solutions and technologies, form the basis of natural technology. Promising concepts are Green Algae water treatment, Decentralised Bio-gas from green waste and sewage, the Living Machine, and heat storage in soils. Most of these natural technologies are based on the use of light for natural processes or the accumulation of warmth in closed systems. By separating the flows from the onset, all nutrients in waste and water can be directly used for these plans. Existing, centralised plans are based on the reverse: different qualities of flows are combined. Therefore the damage has already been done: useable nutrients are mixed with toxic waste. This is quite apart from the fact that decentralised natural technologies, being close to the source, can save energy required for transportation and the maintenance of infrastructure.

2.4 Decentralising energy infrastructure: from energy to exergy

Exergy is the quality of energy - in place, level and time. Exergy is nothing more than using the same amount of generated sustainable energy in such a manner that as many utilities as possible can be extracted from the same energy content (for example the use of incoming sunlight). It originates from the fact that energy can have different levels of quality. Loss during transport and/or use is minimised through better attunement of the required quality of energy and the energy generated. The exergetic approach necessitates a synergy between spatial planning and energy infrastructure.

Nowadays urban planning normally begins with the 'preparation' of the building site. It is important to note that in this situation there is a deviation between the preparation and the actual sustainable (or non-sustainable) urban design. In fact, prior to the actual construction being commenced, the errors have already been made. The upper layer of the building site is treated, usually raised, and an enormous amount of standardised (technical) infrastructure placed under the ground. This is partly a result of ongoing specialisation, and the division between civil engineering and (urban) architecture, and partly due to the tendency of ongoing centralisation, and sometimes globalisation, of normally individual elements such as electricity, water, gas and waste infrastructure. Unlike the search for optimal small-scale alternatives, building new large-scale installations has political priority. The 'technical infrastructure' for the transportation of energy, water and waste is a relatively expensive feature in urban planning. Furthermore it is often subterranean, which reduces the level of 'user' involvement regarding the quantities of the transported 'flows' and therefore negatively influences their behaviour. Another problem is the invisibility of its costs: people cannot directly experience the impact of the usually over-dimensioned infrastructure required for their comfort. When infrastructural costs are directly linked to the amount of use, it will influence people to opt for more passive and decentralised systems. Improving the visibility of the different flows is a major challenge for engineers and designers. First of all there is the non-physical visibility: for example by changing the meter units in the homes from kWh or

m^3 into dollars or the relevant local currency. This visibility could also entail displaying the increase in energy, water or waste due to individual behaviour. Secondly there is the more physical visibility of the infrastructure, and the manner in which the energy, including the wastewater treatment (with its often forgotten energy impact), is being generated.

2.5 Decentralisation of food and waste support

Optimising (which usually means minimising) consumption will assist in making the world more sustainable, in fact it will always be the first step. Breakthrough opportunities should be found in the new passive technologies with a low (non-sustainable) energy impact, leading to increasing capacities with less transport.

Following the principle of 'Not less but differently', 'E-fulfilment' and the 'Retourette' are promising new concepts in this field. E-fulfilment is a logistic concept for e-commerce deliveries on a regional or local scale. A computerised cylindrical miniload is implemented in city districts on an optimum scale (less transport for producer and customer). The Retourette is a successful waste collecting and separating concept on a decentralised but combined scale which attempts to discover the optimum between maximum accessibility for inhabitants/users and a low level of transportation for refuse collecting companies.

2.6 Dematerialization

In comparisons of environmental impact, the transport factor, with its use of (raw) materials, is often omitted, or minimised to the required energy for transport. The actual use of 'goods' (water, fuel, raw materials, etc.) is complex, but has a certain impact. As we become more aware that the price of fuel, water and raw materials will increase tremendously during the next few decades, more emphasis will be placed on the requirement to find solutions which are located as close as possible to the source of the environmental issues. It is self-evident that solutions for achieving a reduction of the previously stated flows must be found in reducing infrastructure, including technical infrastructure, and the need for transport. It will also be necessary to attempt to connect the different flows and their solutions in a more integral fashion. The ongoing specialisation has led to several autarkic concepts that are based on technologies that attempt to find solutions for each of the different flows. For example, biological water treatment is no longer a problem. Its energy utilisation and the ground surface required, however, is still a problem. Therefore linking solutions for these different flows will be necessary: passive energy concepts could utilise heat biomass or even biogas production more during wastewater treatments. Current levels of energy and material use in high-income cities and countries are biophysically unsustainable. Accumulating empirical evidence of ecological degradation calls for a radical transformation of urban industrial society, including prevailing opinions about form and function. Various material flows and waste assimilation studies have shown that in order to attain sustainability, the post-modern world will have to reduce energy and material intensity of consumption by 50%. The necessary dematerialization increases to 80%-90% in the high-income countries (Rees, 2000). New urban construction and infrastructure, even for basic standards, will require enormous quantities of energy and material resources. Buildings (excluding technical infrastructure) account for 40% of global material and about a third of the world energy consumption. Furthermore, only a small section of these buildings are new buildings. In 2040 up to 80% of the built environment will consist of buildings that are already in place today. Therefore greening future urbanisation will have to start with changing the existing built environment: and in particular the forgotten sectors. Through a fundamental change in growth processes and modern-day habits and a radical short-term change in urban planning and organisation, we may save costs in the long term by omitting the need for a subsequent paradigm shift.

3. GRADUAL SUSTAINABLE DEVELOPMENT

3.1 Participation and scale of application

A number of cases relating to various types of urban planning have been chosen in order to examine the possibilities of decentralising natural technologies which attempt to convert the main flows in the built environment into cycles. This research is necessary in order to find the optimum scale for self-sufficiency, with a maximum use of passive and/or 'low-tech' technologies. The selection criteria for these cases are based on various factors: the organisation of the human participation, the type of urban planning and the type of technical infrastructure. This paper focuses on one of the cases selected: 'Lanxmeer'. The first step is to investigate the quantity and quality of the existing flows. Subsequently the current standard measures relating to sustainability are taken and each and every environmental improvement documented. Next the Sustainable Implant (S.I.) can be compounded for the case-specific circumstances. The effects after implementation are analysed, as well as the possible reduction of infrastructure, costs and the required level of maintenance, control and adaptation, and user participation. The results are then verified against the previously stated factor of 20. Conclusions are made concerning the relationship between the manner of participation, the type of urban construction in relationship to decentralising technical infrastructure, and autarkic concepts.

3.2 The instrument: Sustainable Implant

The Sustainable Implant cannot be regarded as a fixed design that can be repeated. The instrument comprises a guiding principle for a sustainable solution to the mainly non-sustainable flows in new or existing neighbourhoods. On a neighbourhood level the S.I. entails the design of a more sustainable main structure for the transportation of water, energy, materials and waste. This structure should also be made flexible, in order to cope with changes relating to sudden future developments (increasing and decreasing flows, improving techniques). Inhabitants could participate in the different processes and their support could be used for the maintenance of the quality levels. The Sustainable Implant is a combination of several decentral, mostly natural concepts. The basis is formed by the previously stated exergy approach: separating the qualities and quantities of the existing flows.
The instrument can be regarded as an interconnection of the water, waste and energy flows, making direct use of the different qualities through its decentralized implementation.



Figure 3 not well working Living Machine, Kolding



Figure 4 Interior Living Machine (J. Todd, Ocean Arks Int.)

The introduction of an S.I., together with other eco-city design principles and green building technologies such as the Living Machine (J. Todd, 1992) [figs 3 and 4], have the necessary potential to make a major contribution to the conservation efforts.
A true paradigm shift could be brought into effect through a reduction in technical infrastructure, the interconnection of the different flows on a non-individual or centralised scale, and the separation of the different qualities within each flow.

3.3 The Sustainable Implant in Lanxmeer Culemborg, the Netherlands

The Lanxmeer Culemborg case has been chosen because of the innovative ecological character of the plan as well as its development [figs. 5 and 6] and the participation of its future users. The technical infrastructure in Lanxmeer is internally decentralised while still externally linked to centralised systems, and therefore comparisons can be made with normal (centralised) city districts. In this context it will be less difficult to incorporate the Sustainable Implant, with its different functions. The research is being carried out by the 'DOSIS' research programme at Delft University of Technology at the request of and in co-operation with the EVA foundation. The EVA foundation strives to realise settlements that are designed in an integral manner and provide conditions for living, working and recreation. Lanxmeer is the first project to be realised. The EVA-Lanxmeer project comprises 200 houses and apartments, ecological office buildings, the EVA Centre and an ecological city farm. The location of EVA Lanxmeer is unique: close to the railway station of Culemborg, a small town which has a protected water collection area, some agricultural land and old ecological orchards. Several other utilities like schools and a swimmingpool have already been incorporated in the site.

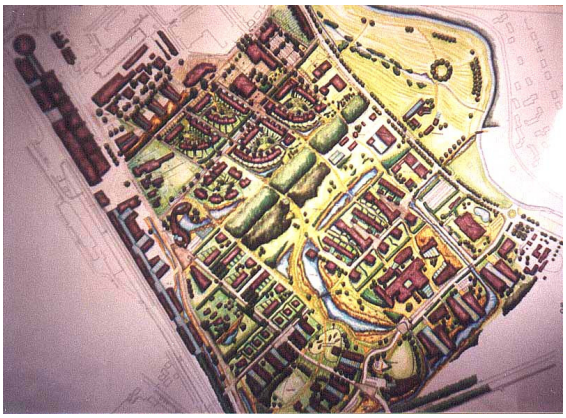

Figure 5 Urban plan ‘Lanxmeer’, Culemborg (Holland); J. Eble.

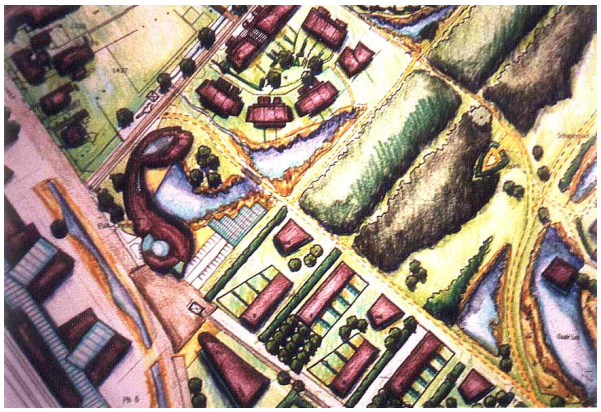

Figure 6 Detail Urban plan and EVA Centre J. Eble, Atelier 2T Architects.

The integration of 'Bau-biology', organic design of the landscape and architecture, and Permaculture principles are incorporated in the EVA concept. The public green space will have a natural character and is partially intended for food production. Inhabitants will have to park their cars on the outskirts of the settlement, due to the sites' ecological conditions.

The first 4 clusters of 30 dwellings are shaped around 'courts'. There is a gradual transition from private space, semi-private space, and public space towards a more natural landscape in the protected zone of the Water Company. Integral water systems have been incorporated in these various zones. Rainwater from the roofs is collected in several ponds and used, together with treated water from the Water Company, in the different households. Lanxmeer will be prototypical for the use of decentral, mostly passive systems. Separate water systems for drinking water and water for domestic use will be installed in all houses, and also

decentralised separate sewage systems for 'grey' and 'black water'. Grey water will be filtered in wetlands close to the S.I. and fed into the surface water. Lanxmeer's sewage effluent together with green kitchen and garden waste will be collected and transported to a central (or rather decentral) building equipped with a combination of several passive energy components, a 'Bio-gas plant', a 'Living Machine', the 'E-fulfilment' miniload, a 'Retourette' and a number of educational functions. This building will be developed as the so-called Sustainable Implant.

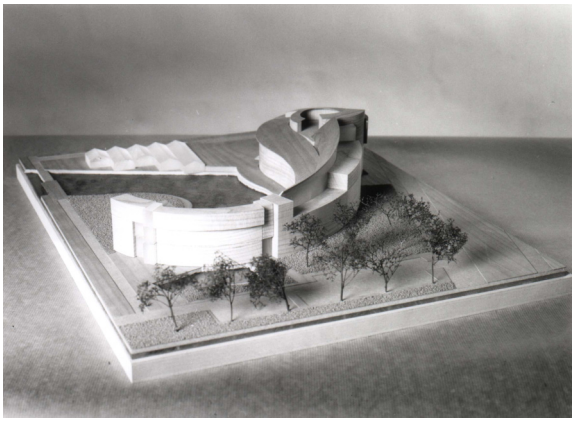

Figure 7 EVA Centre, Concept Maquette with S.I. Atelier 2T Architects



Figure 8 EVA Centre, Concept Maquette with S.I. Atelier 2T Architects

The energy plan for the houses and the EVA Centre is based on low-tech, mostly passive technologies. The Biogas plant within the S.I. plays an important role in this energy concept. The main goal is to make the settlement energy-neutral, with a very low CO_2 emission. The S.I. will be located next to the EVA Centre and will be part of the educational programmes. [figs. 7 and 8]

Two alternatives to the S.I. are being developed. The first attempts to combine the various decentralised technologies in a plan with maximum accessibility due to its educational use together with the EVA Centre. The second alternative attempts to optimise the utilised ground surface, for instance, to maximise the use of natural light for combined use by various processes. In this version, the required ground surface has already been reduced to less than $120m^2$ for the wastewater treatment, waste collection and a substantial fraction of the electricity demand for the 200 households.

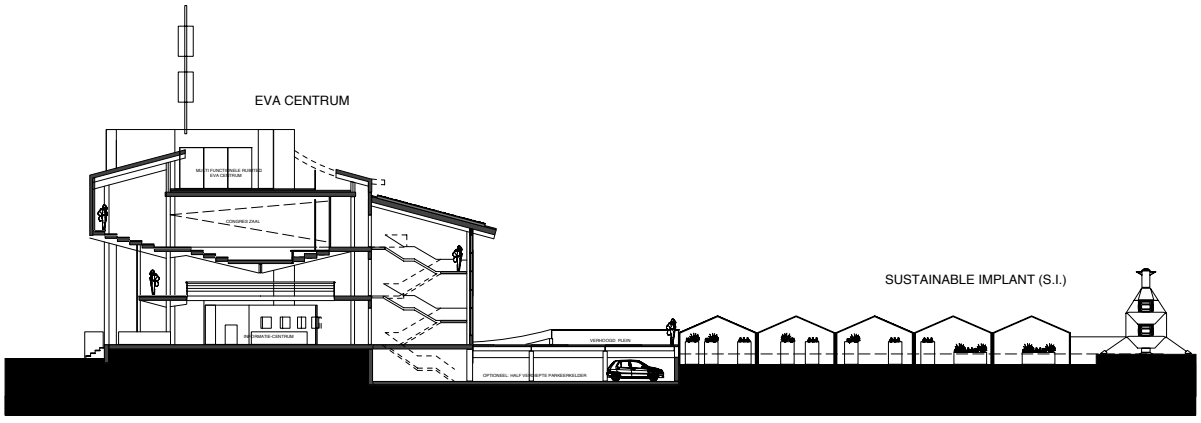

Figure 9 EVA Centre and Sustainable Implant, cross-section, Atelier 2T Architects, Haarlem

The participation process of the inhabitants plays an important role in the process of development. From the onset (1993) a group of interested parties, both professionals and citizens, supported the EVA plan and therefore participated in the process. The S.I. will also have an important educational function and will therefore serve as an example for future devices which will continue to improve on the true sustainability of new or existing areas.

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Decentralised waste collection and separation in city districts - Separating waste flows & increasing visibility of sustainable refuse collection solutions near users

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1. INTRODUCTION

1.1 Centralisation of refuse processing

Refuse is business. The total refuse market in a small country like the Netherlands concerns an annual turnover of $3^1/_2$ billion Euros. Despite several successful green initiatives and public commercials to achieve a shrinkage of refuse citizens, trade and industry produce more refuse every year. Comparing studies of collection totals in the Netherlands from ten years ago with the collected refuse totals of today fortunately also show a clear increase of waste separation per person, with an attendant small decrease of the so called 'rest-refuse' (after separation of 'useful' flows) which are being dumped in incineration furnaces (Avi) or rubbish-tips. Incineration is at this end-of-pipe stage for the general refuse flow a better solution then dumping. At this final stage of processing in the Netherlands still (end 90's) 11% of the refuse flow is being dumped. For comparison: in England this is still 90%.

Ladder van Lansink

1. *Prevention*
2. *Element re-use*
3. *Material re-use*
4. *Useful application*
5. *Incineration with energy recovery*
6. *Incineration*
7. *Landfill/rubbish-tip*

Delft Ladder

1. *Prevention*
2. *Object renovation*
3. *Element re-use*
4. *Material re-use*
5. *Useful application*
6. *Immobilisation with useful application*
7. *Immobilisation*
8. *Incineration with energy recovery*
9. *Incineration*
10. *Landfill/rubbish-tip*

Figure 1: The 'Ladder of Lansink' and the 'Delft Ladder' (Kristinsson/Kowalczyk)

The Dutch government started to use in the last two decades of the past millennium the 'Ladder of Lansink' (after its originator, Ad Lansink, a Dutch MP from 1977 until 1998).

Lansink invented a preference list for refuse processing: prevention, element re-use, material re-use, useful application, incineration with energy recovery, incineration without energy recovery, and finally refuse-tipping or landfill. In 2000 the ladder has been completed for the built environment by Kristinsson (et al) into the 'Delft ladder'[fig. 1]. Since 1996 a law is operative which prohibits tipping refuse that can be re-used or incinerated in Avi's.
Apart from the rules the environment has exerted quiet immensely the administrative side of refuse policy: who is responsible for what? Taken by itself every environmental affair lead to ongoing scaling up. Regulating the over one thousand rubbish tips in the late seventies financially seemed quiet difficult, therefore local governments were obliged to co-operate with their 'neighbours' to organise these final steps of the 'Ladder of Lansink', the rubbish tips. Every local government (city, village, etc.) stayed responsible for the refuse collection, but from 1977 on the refuse policy was being arranged by the regional government. In the 'refuse-consultation-organ' ('Afval Overleg Orgaan', or AOO) local-, regional and national governments worked together responding several questions like, who is responsible for what, where will be situated new or enlarged capacities of incineration furnaces (Avi) and/or rubbish-tips or landfill and who processes which refuse. This 'concession system' flourishes up to today. Therefore the incineration furnaces are ensured of supply, thanks to contracts with local governments and arrangements with the AOO. From 'outside' the district (region) no refuse may be accepted, but inside every province or region an acceptation duty holds good. This means: every region it's own service area with attendant prices. The main goal of the introduction of these AOO's was to keep some force on prevention and re-use and therefore to plan the incineration capacities relatively tight. This resulted in a surplus of combustible refuse (in 1999 2 Mton), that is being tipped by exemption. Today however market influences get stronger and stronger, resulting in a call for removal of the before stated district borders. In the Netherlands now exists an Avi-capacity from more or less 5 Mton while country-wide about 7 Mton combustible refuse is being collected. Therefore people stated (in 1996) that the AOO arrangements were not needed anymore, for the Avi's (incineration furnaces) would get filled anyhow without a distribution plan. Apart from that too many responsibilities (policy, execution and maintenance) came in control of just one party: the regional (provincial) government. These regional governments will have to yield part of their power, and therefore also part of their income (via taxes). This process is difficult. Apart from that, behind all this lies possible improvement of Dutch enterprises in the coming international competition. Therefore preparations were made to free the national refuse market and to get rid of the district borders (provinces). The bill is now in the parliament. Problem however is the interest of the local governments. A strange duality exists as the interests of local governments, who mostly are the main shareholder or own (about 72% of) the Avi's, are opposite to that from the more and more privatised Avi's. Main reason is the fear for financial catastrophes now that main shareholders in the field seem to be put aside. Especially the local governments in places with relatively high rates and/or nearby bigger incineration furnaces are afraid of a decrease of the refuse flow with growing costs for their furnaces. They fear ongoing price competition resulting in unoccupation of expensive Avi's. Under the existing AOO system local governments entered into risky contracts with ('their') Avi's, in which they –some more than others- obliged themselves to fixed quantities of refuse and fixed (high) prices, while they –for they are main shareholders- also are responsible for possible losses in exploitation. The differences are enormous: some local governments earn money with their incineration of refuse while others groan under heavy taxation contracts. This last category of city governments has got a double risk: they are not able to offer 'their' refuse without restraint in the market, while they also are responsible for possible losses of 'their' Avi's. To avoid this problem of Avi's without sufficient supply in 1996 a law was approved which discourages tipping by imposing it. The idea was to raise this

imposition in the next four years in such a way that tipping would cost the same as incineration (about 100 Euro per tonne). The Dutch minister Pronk supposes that this imposition will function as a minimum fare for incineration.

1.2 Modernisation of the refuse market

Dutch trade and industry however is afraid for higher tariffs because of the lack of incineration capacity. This problem is being solved by a concept bill, which makes it possible for the Dutch minister to intervene when tariffs get to high. A second problem is the modernisation of some of the older Avi's. The sector says they can solve this problem by taking them over by other Avi's, but they state that it is necessary to work on a bigger scale. A third problem of the existing system is the possibility of exportation of refuse to other countries. In accordance with the regulations this is only possible when 'the refuse gets a useful application'. But the term 'useful' in this case always stays a subject of discussion. Officially refuse only can be exported to foreign countries when it is used for as fuel, when generating electricity is the main goal. Incineration of refuse in foreign countries however is not possible within these regulations, for the main goal stays wiping out the refuse.
The ever-continuing centralisation, or even globalisation of refuse processing seems a way of no return. The initiated higher tipping tariffs provoke possible raise of exportation of refuse to other countries (with softer rules), which in turn provokes empty Avi's in the Netherlands with coming lower tax incomes for the local, regional and even national government. Opening the market in fact could lead to more competition resulting in lower prices for consumers. The local governments however want to get rid of their venture risks by privatising their Avi's. This would lead to price increases due to needed external capital and higher profits.
The expectation is however that the European borders for transportation of refuse will open the next decade. The earlier stated Dutch regulations which makes international transport of refuse only possible when it will be applied useful already means a possible transportation of 75% of the Dutch refuse totals. This means possibilities for profitable trade, especially when refuse is being offered separately. Several fusion's of smaller refuse businesses run ahead of this expectation. Apart from that the opening of the (Dutch) energy market introduces new proprietors. The possibilities of 'green' electricity through incineration of refuse already made them buy up to about one third of the Dutch incineration capacity. What results are big recycling companies with a wide spread range of services. Some decades ago the companies in the field were horizontally organised. The market consisted of collectors, Avi's, transporters and companies or specialised in a certain flow (part) of refuse. Nowadays these bigger 'recycling companies' control the whole refuse chain for all fractions (and scales).

2. REFUSE COLLECTION AND SEPARATION IN CITY-DISTRICTS

2.1 Domestic waste

One of the changing aspects due to the ongoing modernisation and liberalisation of the refuse market are the new initiatives concerning collection and separation of 'useful' waste. The separated flows of refuse still mainly concern glass, 'green'refuse (gft), paper and so-called small chemical waste (batteries, paint and etceteras). Each year in the Netherlands for instance 25 kilogram per person of glass waste is being separated. Via magnets 80% of the metal packing also is separated, although this is done without separation of this 'flow' apart from the collected main refuse flow. An ingenious machine, which cuts the separated metals in little pieces and fires them away, determines the sort of metal, depending on the distance and place of landing.

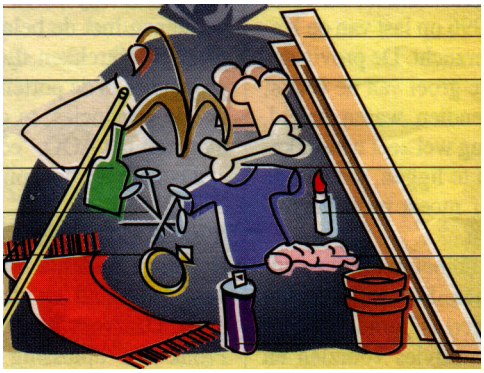
Green refuse 31,7% Paper 31,4% Plastics 11,2% Glass 3,3% Iron 3,4% Other metals 0,8% Carpets and mats 0,9%		Wood 2,1% Bread 2,1% Animal waste 1,6% Textiles 2,9% Special refuse 0,4% Leather and rubber 0,9% Ceramics 7,1% Small chemicals 0,4%

Figure 2: The content of a Dutch waste disposal bag (1997)

Still more than half of refuse in the Netherlands is being offered unseparated [fig. 3]. The refuse cart still is collecting about 80% of the total amount of refuse while it could be about 30%. Apart from that, in the last decade flows like the construction-waste and used paper increased due to the economical prosperity, while both flows can be separated relatively easily. In Amsterdam in 2000 about 8.624 kilograms collected refuse has been investigated and sorted into 26 different fractions. Although about 70% of refuse consists of green refuse, re-useable paper, glass, textile, small chemicals and domestic pieces of apparatus only 18% of the refuse in this investigation was being offered separately. Striking was the amount of paper that was found in the waste disposal bags (17% of the total weight). In city-districts in which paper is being collected at the doors this percentage was better: about 40% of the totals of used paper refuse was collected.

2.2 Pay-per-weight (Diftar)

In 22% of the Dutch municipalities (for about 12,6% of the Dutch population) refuse is being collected via a new system in which citizens pay per weight of offered refuse [fig. 3]. Most of these municipalities impose money depending on the amount of times the container is being emptied. In the other municipalities, representing about 2,7% of the Dutch population, people pay for their refuse per offered kilogram. This system of collection, called Diftar (differentiated tariff's), still is disputed but a recent investigation (Allers, Kooreman, 2002) shows the positive effects of this system of refuse collection.

In the municipality Oostzaan the introduction of the system lead to a permanent reduction of refuse with about 30%. The municipality has controlled the changes and possible side-effects detailed. They even sampled the sewers. Illegal dumping of refuse 'wasn't as worse as expected' while only for about 5% of the refuse was being fenced with offering it at peoples employers or family. Oostzaan however obtains an a-typical municipality (for the political 'green' parties are bigger than in the rest of the Netherlands). In the other municipalities that introduced the Diftar system the refuse totals also decreased. The amount of reduction depends on the price per kilogram (in Oostzaan at the moment of introduction it was about 20 Eurocent per kilogram). When the price per kilogram refuse is too low, the necessary prickle misses to be(come) economical with ones waste. But a relative high price per kilogram evokes easier evasion or dumping. In the northern municipality of Haren, in which 40% less green refuse and 23% less 'general' refuse was being collected, up to 70% of the people in the beginning exposed certain behaviour of evasion. It should be stated that these people didn't take all their refuse to other places but only a small part of it. This kind of behaviour however decreases some time after implementation. Important in this case is the need for people to see that the system not only reduces the collected totals, but also results to lower prices for themselves.

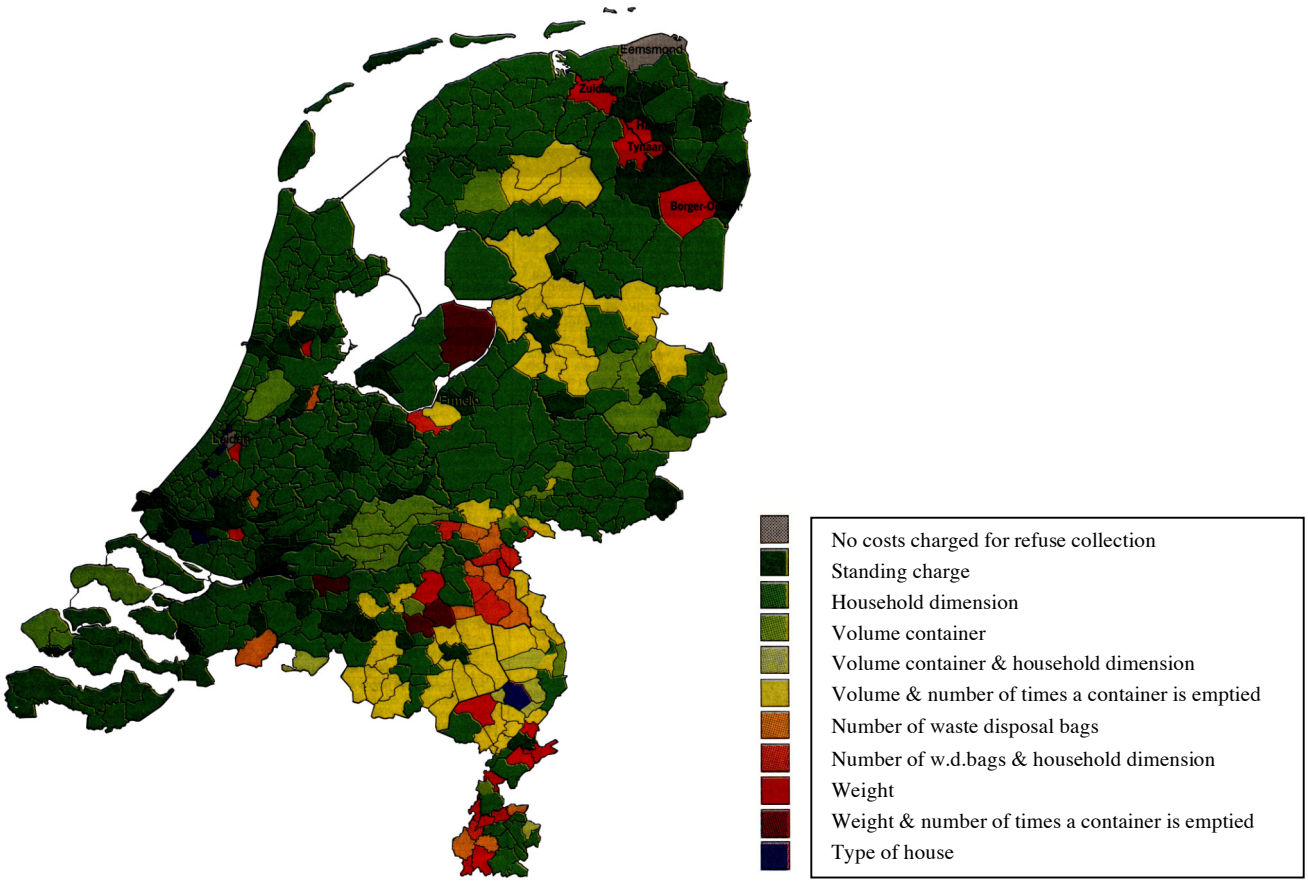


Figure 3: The tariff systems in the Netherlands (2001)

The Diftar system in general needs certain 'social control'. Apart from that most of the municipalities also introduced controllers themselves. It is because of this need for social control that up to now the 22 municipalities concerned small ones. In 2004 two bigger municipalities in the Netherlands (Apeldoorn and Nijmegen) also will introduce the system.

2.3 Decentralising recycling and integrating collection of separated flows in buildings

Recycling of useful parts of refuse, especially glass, paper and small chemicals (batteries), in the Netherlands is organised relatively well and therefore also relatively successful. Glass for instance is being collected in 25.000 glass containers through out the country. Nevertheless the Dutch government wants to increase the collected flows. Apart from that they want to start collecting other flows. In several cities and municipalities therefore a new concept is being subsidised in which people can bring these different 'fractions' near to their houses. These concepts, known under the names 'Retourette' or 'Recycle Shop', mostly are combined with supermarkets to initiate win-win situations. Inside these Retourette's people can deliver up to 16 different fractions of refuse. Some of these fractions or 'flows' are connected to deposit money, most of them however still aren't. The idea is to combine transportation from these decentralised collection buildings towards the regional division- and collection points that are, due to ongoing centralisation, situated at ever increasing distances. Apart from that the possibility to bring more and different fragments gives people the opportunity to walk some steps ahead of regulations concerning the environment in municipalities where the Diftar system still isn't introduced. In municipalities in which the Diftar system has been introduced the concept generally works anyhow. People can by separating more and different flows save some weight in their deposit containers and therefore save money. Special emphasis is being

given to the design of these 'Recycle Shops'. Most of them are designed in such a way that they address especially to children. The back-ground of these new buildings is the belief that it will be easier to realise and maintain further going refuse separation and the pursued replacement of the existing (centralised) technologies by introducing decentralised solutions like the Retourette. The introduction nearer to the people inside a well designed building tries to support the needed shift in acting and thinking: Waste needs to be treated as 'raw material'. To achieve this goal the final step in this process should be the introduction of governments or privates that pay for separately offered refuse fractions in stead of people paying for their waste. Of course this should be combined with the full-scale introduction of deposit money for use of raw materials in (all) product prices.

3. EFFECTS OF DECENTRALISED REFUSE COLLECTION BUILDINGS

3.1 Introduction

In 2001 a research has been carried out by the Delft University of Technology concerning the effects of the introduction of the formerly stated decentralised waste collection buildings like the 'Retourette' in Tynaarlo and the 'Recycle shop' in Haarlem, both in the Netherlands. The research represents an inquiry among almost 2000 persons. Comparisons have been made in the introduction of these concepts in city districts and villages with high-densities versus low-densities, cities in which waste collection is free of offered weight and cities where people have to pay for the amount (or weight) of offered waste for (centralised) collection by garbage trucks (Diftar). Secondary effects of the formerly stated differences also have been investigated. Other factors that have been analysed are the suitability within a social acceptable form (integration), possible educational meaning and the cost factor in relation to energy-, water- and material efficiency of the concepts.

3.2 Diftar vs. non-Diftar municipalities

In the investigated cases in which there wasn't a Diftar-system operative in the municipality the introduction of a Recycle Shop or Retourette did show interesting collection totals. After the collection of more or less 'usual fractions like paper and glass (69% and 66% of the people brought these fractions) people mostly brought tetra packaging (28%), plastic flacons (22%), tin (19%), small chemicals (10%), textiles (6%) and shoes (4%). About 70% of the people newly started to bring- and separate different fractions of refuse since the Recycle Shop gives them a possibility to turn it in. Especially the collection of tetra packaging, plastic flacons and tin increases (respectively 49%, 48% and 38%). But even the collection totals of small chemicals (33%), textiles (28%) and shoes (25%) increase significantly. The collection totals of the more usual fractions paper and glass, increase with a small 5%.

The collection of all 8 investigated fragments of refuse in municipalities in which the Diftar system was introduced increased even more significantly. Especially the collection of tetra-packaging (72% of the people who came to the Retourette), plastic flacons (63%) and tin (52%) increased enormously. But it is not just the amount (or weight) that changes. People also turn in more (different)fractions and more weight at once (taking boxes in stead of bags). Most of the times this results in the need to transport it by car (two times as many people) or by bicycle (20% more people) in stead of going by foot. At the same time people are willing to cover a longer distance to bring their separated refuse (with high-flyers up to over 10 kms). The biggest group of people comes from a distance below the 3 kilometres from the collection site. Apart from that the frequency of bringing separated refuse increases too. About two third of the people comes in between one or two times a week. Since the investigated buildings were clustered to commercial activities (in the investigated cases supermarkets), who most of

the times own and therefore supervise these buildings, more clients came to visit these businesses. Only in between 7 to 13% of the people didn't combine their visit of the Recycle Shop with a visit to the business of its owner. More than 10% of the people however say not having visited the attending business before, but after the introduction of the Recycle Shop do visit it regularly. This facet is interesting for the initiators for they see these concepts as part of their businesses. For them it is just another way of offering services to attract more people and therefore make higher profits. In the case of the Recycle Shop in the non-Diftar city of Haarlem the proprietor has invested Euro 320.000 (including the purchase of the –existing-building). The project was subsidised by the local government a/o. (overall Euro 220.000). Apart from that a local Recycle Business, who is responsible for the transportation of some of the collected flows from this Recycle Shop, pays for half the wage of a person (about Euro 5500) every year for personnel costs. In the case of the Diftar municipality of Tynaarlo the total investments were much less for the collection was being arranged inside the new built supermarket. The overall investment in this case was only Euro 100.000. The collection totals are better in the Diftar municipalities, but even in the case of the Recycle Shop in Haarlem (which still has mainly a neighbourhood function for about 16.000 persons) quite surprising amounts are being collected: paper average 23m^3/week; tetra 2,8m^3/week; plastic flacons 1,4m^3/week; glass 11m^3/week; tin 1,2m^3/week; textile 10m^3/week. In this case it is important to notify that in the neighbourhood in 4 other places the 'usual' glass and paper is being collected. The majority of people combine their visit to the Recycle Shop with their everyday shopping (supermarket). In cases in which the Recycle Shop is being located strategically, for instance at an in- or exit route of a city more people (up to 31%) bring their separated refuse without any direct connected visit to the commercial shop that owns the Recycle Shop.
Almost all these Recycle Shops have been designed with extra emphasis at the target group of children. The idea is to educate these 'new' citizens at an early stage. An interesting outcome of the research however is that a big majority of the people that bring their separated refuse isn't being attracted to the concept for this reason. Moreover they even don't like this childish stigma "for such a serious matter as recycling" as several people stated. They do however underscore the need for a good and aesthetic design, not only for a better control, maintenance and use but most of all to show the need and seriousness of recycling.

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The Environmental Impact of Domestic Kitchens

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1 INTRODUCTION

All buildings impact on the environment throughout their life-cycle via the use of material resources and the disposal of wastes. This impact commences with the winning of the raw materials and ends with the final disposal of materials after the demolition and re-use or recycling of suitable components.

Moreover, total environmental impact and burden of a building will include the resources used to operate, maintain and refurbish the building within this lifespan. As a consequence the environmental burden of a building will depend on the mode of construction, the efficiency of operation and maintenance and maximising the potential of materials at the time of demolition via designing for disassembly.

This paper identifies the significance of evaluating the impact of kitchen components as a major contributor to the environmental impact of domestic dwellings. This is notable not only due to the intensity of valuable material resources installed but also because of the number of times the components are replaced within the lifetime of the building. Indeed kitchen refurbishment often occurs long before individual components have reached the end of their useful life.

2 ENVIRONMENTAL IMPACTS OF KITCHEN REFURBISHMENT

Kitchen components are a major influence in the evaluation of the sustainability of domestic dwelling refurbishment due to the wide range of disparate materials, assemblies and appliances. The environmental aspects encompassed are numerous whilst the opportunity to make "green" decisions due to material specification and energy efficient goods compound the issue of sustainable design and use. In addition the kitchen is one area of the house that is likely to be replaced or refurbished before the individual elements have come to the end of their useful life.

The environmental implications offered by a kitchen refurbishment activity therefore embrace aspects throughout the whole life-cycle of the components involved in the replacement. The environmental burden is the result of the impacts of the huge range of different materials together with the processes involved in the manufacture, renovation, use and end-use of the kitchen components.

2.1 Environmental impacts related to materials.

The variety of materials that can be found in kitchen is extensive because the supply of choices offered by the market varying upon type, quality, aesthetics, technological innovation and price.
There are many environmental aspects that are distinct to some materials or their processes. For example, the depletion of non renewable resources such as tropical hardwoods and stone (granite, slate etc.) and the extraction of metal ores and clay result in a significant increase in environmental impact due to both extraction and transportation.

The embodied energy in kitchen materials range from low values for most of the timber based products to the highest values of metals. It is moderate in minerals (ceramics, stones, glass etc.) and higher in plastics or where the content of energy intensive resins is significant such as in acrylic/mineral composite products, as Corian® and Asterite® as used in modern sinks. The energy embodied is an important indicator as it reflects the consumption in all the processes from the primary raw materials including, in most the cases, transport implications and, further, it can be correlated to CO_2 emissions.

Table 1 identifies embodied energy values for individual material elements used in the construction of kitchens. However it does not include energy consumed in the manufacture of the kitchen components such as wall or base units which are made up of many different materials, whilst the influence of the transportation of some kitchen components should not be underestimated. For example, factory-assembled kitchen units have been shown to consume more transport energy than 20 tonnes of structural masonry over the lifetime of a house [Critchley 2000]. One reason is that the popular hardwood units are almost totally imported from oversea [Hampton 2000] whilst some intermediate materials (e.g. softwood) are traded world-wide. This results in greater energy costs.

Table 1 also illustrates the range of life expectancy values. Specifications and reasons upon the variability of the values are largely discussed later in this paper. In first instance, it may be observed the important correlation between life expectancy and embodied energy values. Whereas the life expectancy of kitchen unit ranges between a minimum value of 6 to 40 years, the embodied energy of the materials of which the unit is composed will load up to six times on the whole life-cycle of a building (assuming a building life span of 60 years).

Whilst a kitchen may be designed or refurbished with low energy intensive materials, such as timber base products, the environmental load when the kitchen is finally fitted may thus result higher than anticipated. This is due to the variety of quantities and qualities in use, the transport implications and the inherent replacement factor of the components.

Table 1 Specifications on kitchen components

COMPONENTS	*Life expectancy (year)*	*Reference*	*Typical materials*	*Embodied Energy (MJ/kg)*	*Reference*
UNITS, DOORS & WORKTOP					
Floor unit	6-35	[BMI 2001]	Softwood	5 - 9	[West et al. 1994]
Base unit	6-40	[BMI 2001]	Hardwood	0.7 - 10	[West et al. 1994]
Doors	5-20	[Construction Audit 1999]	Chipboard	8	[Lawson 1995]
Carcass	5-20	[Construction Audit 1999]	MDF	11.3	[Lawson 1995]
Postformed laminated worktop	5-20	[Construction Audit 1999]			
FLOOR					
Ceramic tiles - glazed	5-20	[Construction Audit 1999]	Vinyl flooring	79.7	[Alcorn 1996]
Ceramic tiles - unglazed	10-30	[BMI 2001]	Chipboard flooring	4	[Howard 1991]
Linoleum	0-50	[BMI 2001]	Harwood flooring	79.1	[Alcorn 1996]
Parquet tiles	6-100	[BMI 2001]	Linoleum flooring	116	[Alcorn 1996]
Vinyl sheet	6-40	[BMI 2001]	Clay	2.7 - 3.4	[CIRIA 1995]
Vinyl tiles	0-40	[BMI 2001]	Granite, local	5.9	[Lawson 1995]
			Granite, imported	13.9	[Lawson 1995]
			Stone	4	[CIRIA 1995]
APPPLIANCES					
Sink acrylic/quartz composite	35	[Construction Audit 1999]	Aluminium	180-250	[CIRIA 1995]
Sink stainless steel	20-35	[Construction Audit 1999]	Copper	70	[CIRIA 1995]
Sink china	35	[Construction Audit 1999]	Steel	25-33	[CIRIA 1995]
Cooker – electric	12	[Cooper 2000]	Steel stainless	11	[CIRIA 1995]
Dishwasher	9	[Cooper 2000]	Zinc	65	[CIRIA 1995]
Freezer standard	11	[Cooper 2000]			
Refrigerator standard	11	[Cooper 2000]			

2.2 Environmental impacts related to use.

The replacement of white goods, as cooker, refrigerator, dishwasher and washing machine (which is often present in a kitchen) with new energy and water use efficiency appliances is an obvious consequence of any kitchen refurbishment. Currently, kitchen appliances use up to 45 per cent less energy than models manufactured 30 years ago and low water consuming items may allow a significant reduction of the daily water use in domestic houses. Savings of 50 litres and 2.5 litres of water per cycle are estimated respectively in new washing machines and dishwashers [Howarth 2000:63].

2.3 Aspects related the end-of-use

The variety of materials and components found in a kitchen is reflected in the multi-formity of end-of-use items when they are replaced with the new ones. Many components that are removed from a kitchen are in principle suitable for direct reuse or recycling but, in practice, the opportunities are limited as specific arrangements for collection and redistribution are required and not always sustainable from an economic point of view. The current use of secondary kitchen units is limited and is more common in small-scale projects for renovation in private DIY. On the other hand, the market of second-hand appliances is well established.

End-used kitchen components from DIY renovations may be brought to civil amenity sites or put in builders' skips together with the other construction and demolition waste. Invariably in this case, the quantity of materials reclaimed and recycled remains small. It is feasible to recycle wood waste for pulp and particle board (chipboard, MDF) on a commercial basis but it can be difficult to recover laminated boards containing adhesives and treated wood products (from melamine laminated units and worktops). Landfill disposal remains the most common option for the end-used kitchen components that are impractical to reuse or recycle.

3 LIFE-CYCLE OF DOMESTIC KITCHENS

In general, when a Life Cycle Assessment is carried out on a building, material or service, the assumptions on the time of life, defined also either *life expectancy* or *service life*, of the referred item are the earliest central presuppositions together with the considerations if the refurbishment and maintenance cycle is to be considered in the study. This is an essential point in studying domestic kitchen refurbishment and putting it in the context of the whole lifecycle of a building.

The lifetime of UK buildings may range from a most frequent published figure of 60 years to value above 100 years as it is suggested by recent research and estimations [Edwards and al. 2000:117]. This is presumable from the fact that 45 per cent of the English building stock is older than 50 years. The useful life of a building can be greatly affected by the timeliness and the quality of maintenance undertaken. In order to consider the effects of repair and refurbishment during the lifetime of a building, considerations and decisions have to be made about the *replacement interval/cycle* of building components. Some of them, in fact, due to their high replacement factor, could result in a significant frequency of impacts on the environment.

3.1 Frequency and reasons for kitchen replacement

Generally, replacement work to building interiors occurs more frequently than exterior structural components. Further, redecoration and refurbishment may be undertaken for cosmetic or fashion reasons rather than because they affect the longevity on function of the building or the durability of building components. This is particularly valid, in domestic dwellings, for kitchen fittings.

In the domestic housing market, the kitchen often infers the economic value of the residence and it is the room which much more than others may impress the potential buyers if it meets their satisfaction and taste. Because of this, the owners wanting to sell their property often undertake improvements in the kitchen following the current trends to increase the value of the property. Nevertheless, if the property's kitchen does not meet the expectations, it is probably the first feature to be renovated when the new owner moves in. Everyone likes to give their personal footprint to their "shelter" and the kitchen is certainly one of the most habitated rooms. Furthermore, the kitchen is highly susceptible to refurbishment as it may succumb to outdated styles or operation and dilapidation due to intense use.

3.2 Functional and aesthetic service life (obsolescence)

The previous considerations drive to the important distinction between *functional service life* and the *aesthetic service life* as defined by Paulsen [1999]. Further research is being undertaken on estimation methods [Bartlett and al. 1998].

The *service life* is defined as the "period of time after installation during which all conditions of the building or a building part meet or exceed the performance requirements" [ISO 1998]. The functionality of a part depends upon the inherent quality of the materials; the aesthetics follow from the reasons already discussed. Thus, the *aesthetic service life* of components, especially in a kitchen, may be greatly different from the *functional service life*. The fashion factor may have a greater influence on the service life than technical factors and, consequently, the replacement interval of kitchen fittings may sometimes be short. At least, it may be smaller than the durability span predicted by the manufacture.

3.3 Quantification of service life

Most published references on typical replacement intervals of building components and services are based upon their durability or the functional performance. The functional service life of kitchen fittings may range around predicted lifetime by the manufacture but it is affected by a complex interaction among several agents that vary accordingly to type and quality of the materials, their physical and mechanical characteristics. Additional factors such as mode of installation, condition of the internal envelope in relation to moisture ingress and maintenance in use subsequently return service life values within a range of 6 to 35 years as identified in Table 1.

3.4 Estimation of aesthetic life or real replacement turnover

Problems occur on the estimation of the aesthetic service life because there are no rules in kitchen improvements due to obsolescence. A practical determination of real service life of domestic components is based on the extended lifetime from the installation to replacement of them. Properly, this may be defined the *real replacement turnover*.

From the data illustrated in Table 1 it may be assumed that the information from the Building Surveyors are the most reliable about the real replacement frequencies as the data come from real observations inside domestic dwellings. There is a range of variability that can reflect early replacements justified by premature failure or by unnecessary replacement undertaken for aesthetic reasons. This is supported by economical surveys on the DIY market that returns an increase in kitchen refurbishment following buoyant housing market [Hampton 2000].

4 CONCLUSIONS

The environmental impact and burdens associated with the manufacture and use of domestic kitchen components are significant due to material use and refurbishment cycles experienced over the lifespan of a dwelling.

This research proposes to adopt a LCA methodology based on accepted ISO 14040 series practices. The environmental impacts and burdens will be quantified via the design and implementation of a computer program that will assess and model the disparate material elements associated with domestic kitchen components. Characterisation and classification of burdens will follow *BRE environmental profiles* [Howard et al 1999] protocols. In addition the qualitative consideration of aesthetic service life will be reviewed via survey analysis.

The study will investigate a distinct eco-profile on domestic kitchen replacement via the quantification of the material use and impacts associated with the refurbishment of local government housing. Primary data on material and energy inputs will be determined by the assessment of all upstream processes associated with the manufacture of worktops, sink, storage units, floor covering and integral electrical cooker and gas burner hob.

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Environmental indicators for the construction and property sector

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1 ABSTRACT

It is generally accepted that the construction and property sector is one of the most important sectors in establishing sustainable development. As a consequence of the initiatives taken by the United Nations (Agenda 21, Habitat protocol, Kyoto protocol, etc.) the consciousness about environmental questions has increased. The building sector contributes a considerable part of the total environmental burden. On a global scale, the sector consumes 40% of all resources and contributes with 40% of emissions of CO_2 and 40% of waste production. The sector also includes about 40.000 – 50.000 types of products of which many contain environmentally dangerous substances.

In the Nordic countries (Sweden, Norway, Finland, Denmark and Iceland) work has been carried out to develop and formulate practical environmental goals for the building industry based on national goals using environmental indicators. It is very important that the building industry will succeed in reducing the environmental burden and minimize the use of materials and resources.

2 KEYWORDS

Sustainable development, environmental indicators, calculation framework, environmental burden.

3 INTRODUCTION

Companies and property owners, which are interested in showing their progress in environmental activities and responsibilities, can use indicators to follow up their efforts. The construction and property sector is not different from other branches in this matter. Benchmarking is one way to compare progress and results within a company over a period of time, and to compare one company to another.
This Nordic project was established in 1999 to develop a framework and a set of indicators to assist in a comparison or to carry out assessment of buildings or building management

systems concerning environmental burdens. The framework is developed for a coherent and simple calculation and presentation of environmental burdens from buildings.
Environmental issues are complicated and will be a function of both time and place and do also have relation to other aspects. It can be a difficult task to try to simplify and minimize the numbers of relevant factors without missing the main goal. In this Nordic project a set of environmental indicators has been developed for use in management of properties and they have been tested out on different types of buildings.
The indicators cover areas like human health and comfort, use of resources (energy, water, materials) and dangerous substances, emissions, and waste. Indicators and key figures will always simplify the reality and are an intelligent method to give an overview regarding complicated and not too well known factors for practical use.
The main goals for the project have been:

- To develop a set of indicators that can help the property sector to demonstrate their environmental policy according to ISO 14000 and EMAS.
- To help the property sector to minimize environmental burdens from buildings and building management.

4 ENVIRONMENTAL INDICATORS

Environmental indicators must be easy to use and interpret and related to measurable properties. They should be based on international standards or common practice. The criteria for selecting indicators has been to:

- Provide a representative picture of an environmental condition of the property sector's status concerning environmental burden
- Be simple, easy to interpret and able to show trends over time
- Be responsive to quick changes in the environment related to human activities
- Provide a basis for international comparisons
- Be well founded in technical and scientific terms
- Be based on international standards and an international consensus concerning its validity
- Adequately documented and of known quality
- Updated at regular intervals in accordance with reliable procedures

In this project the environmental indicators will be related to five main areas:

- Human health and comfort
- Resources
- External environment
- Waste
- Chemicals

The project group has been working with these indicators on many levels. First level indicators are for comparison between countries (benchmarking) and more detail levels for use on buildings or building complex management systems.
Examples of first level environmental indicators are:

- Human health and comfort: indoor environment (% of complaints)
- Resources: use of energy, material, water and area
- External environment: emissions to air

- Waste: building waste, household waste
- Chemicals: detergents, paints
- Environmental policy: strategy, goals and management system

It is necessary to have different references figures or key values for different types of buildings or building methods. Therefore in all the Nordic countries work has been carried out to find these key values for different types of buildings (dwellings, office buildings, schools and shops).

In the project group many studies have been carried out for various types of environmental indicators. As an example a theoretical study of possible indicators of waste is described in 4.1.

4.1 Environmental indicators:

Waste

A theoretical outline for a waste indicator has been developed. The waste indicator, Q, is the total waste expressed in kg/m^2 or in kg/ person, year.
For the time being, there is not sufficient information to define Q. However, theoretically it would be possible to define it as described below.

$$Q = (Q_n + Q_o + Q_d) \quad [1]$$

where

Q_n = indicator for new buildings, i.e. building production
Q_o = indicator for operation
Q_d = indicator for demolition

In literature, benchmark values can be found for the indicators above; (Q_n, 30 kg/m^2, Q_o, 30-300 kg/m^2, and Q_d, 700-1300 kg/m^2).
The service life of a building is set to 60 years. In order to take into account the actual durability, D, a durability factor 60/D is included in the equation. In this way, buildings with a service life longer than 60 years are favoured.

$$Q = (Q_n + Q_o + Q_d) * 60/D \quad [2]$$

Each process (production, operation and demolition) increases the waste. In turn, the waste from each process can be handled in four different ways; recycling, energy recovery, landfill or as dangerous materials.
These four ways are assessed with regard to the environmental consequence and landfill is set to 1. Energy recovery, α, is considered to be better than landfill, recycling is better than energy recovery, β, and dangerous materials, γ , is considered to be worse than landfill. From this follows that

Landfill = 1
α (energy recovery) = < 1
β (recycling) = < α
γ, (dangerous materials) = >1

The equation [2] can be further refined as follows:

$$Q_n = A*q_{n1} + Q_{n1} + \alpha_n*q_{n2} + \alpha_n* Q_{n2} + \beta_n* A* q_{n3} + \beta_n* Q_{n3} + \gamma_n*A*q_{n4} + \gamma_n*Q_{n4}$$ (the same for Q_o and Q_d) [3]

where

A = the total amount of a specific material
q_{n1}, q_{n2}, q_{n3}, q_{n4} = assessed percent of material to landfill, for heat recovery, for recycling and as dangerous materials

Q_{n1}, Q_{n2}, Q_{n3}, Q_{n4} = amounts already delivered to landfill, energy recovery, recycling or as dangerous materials

Several issues in this outline need to be discussed. One will be the relation between landfill, energy recovery, recycling, and dangerous materials. Another issue is whether for example energy recovery of waste from new buildings is equal to energy recovery of demolished buildings.

The shown study is more theoretical than practical and the waste indicator used in the project is Q with unit kg/m^2 year or kg/ person year.

Human health and comfort

The indicator for human health and comfort, is measured as % of users dissatisfied of:

- factors like draught, temperature, acoustics, air quality and daylight.

Resources

The indicators are:

- Use of energy (kwh/m^2 year)
- Use of materials (kg/m^2 year)
- Use of water (m^3/m^2 year)
- Use of area (m^2)

Use of resources includes both renewable and non-renewable resources.
Renewable resources are reproduced. Examples of renewable resources are biological resources like wood and straw and water resources like ground water and surface water.
Non-renewable resources are oil, coal, gas and metals.

Use of fuels

Depletion of fuels is mainly related to energy production, but energy production does not necessarily mean consumption of fossil fuels, as energy can be produced from hydro power, wind power and solar cells, that do not consume fuels but may give other environmental impacts.
Renewable resources as wood and straw are often excluded from the calculations. Emissions from used renewable resources are not included since the same amount of emission is absorbed under the growth.
The most important non-renewable resources used as fuel are coal, oil and natural gas.

Use of materials

Materials are used for production, maintenance and renovation of buildings. Some materials may be reused when the building is renovated or removed and they are not necessarily lost because they are used in a building. Materials that are reused can in a LCA be subtracted from the total consumption.
Renewable materials (reproduced fast enough to fulfil the consumption) and material that exists in very large amounts (sand, gravel) may not be included in the LCA.

Use of water resources

Water is a renewable resource, but in many places consumption of water is too large or the water is contaminated so it cannot match the consumption. In other places there is no lack of clean water. Whether water should be included as an environmental effect depends on the local conditions. Related to buildings the consumption in the user phase will be dominating.

Land use (change of bio-diversity)
Quantitative methods for evaluation of land use have not been focused on in this project. A contemporary method is used in the GBC-model where the total area is calculated together with information of former status (nature, agriculture, ..).

External environment
The indicators are:

- Global warming (kg CO_2-ekv / m^2 year)
- Acidification (mg SO_2-ekv / m^2 year)
- Formation of photo-oxidants (mg eten-ekv / m^2 year)
- Eutrophication (mg PO_4-ekv /m^2 year)

Indicators related to airborne emissions incorporate impacts of both the efficiency of energy (and materials) use in the building or the company, the quality of energy carriers (and materials) used and efficiency of processes applied in producing energy (and materials). Hence, it is important to note these indicators measure not only the performance of the building or company but also the performance of value chains external to the company.

Chemicals
The indicators are:

- Quantity of chemicals (kg / m^2 year)
- Use of detergent cleaner (kg / m^2 year)
- Use of paint and varnish (kg / m^2 year)

5 CALCULATION FRAMEWORKS

Data is collected and a set of indicators is automatically calculated by using an Excel-sheet. This tool has been developed to cover indicators on both company level and building level and can be used for new or existing buildings. A questionnaire, covering human health and comfort, forms the basis for the health-aspect indicators.
The excel-sheet operates in all the five Nordic languages and calculates all necessary factors and indicators, which have been developed in the framework. The framework is now in use in the Nordic countries and will be thoroughly tested before this project is finished.
The value, for the property owners, of having a set of environmental indicators is supposed to be large and will in many ways help the owners to improve their environmental performance. To measure environmental burdens from buildings and compare them with key figures will show the potential of the improvement. In a systematic way measurements can be carried out and environmental benefits documented by using the indicators (pressure-state-respond model).

6 TESTED DATA IN THE NORDIC COUNTRIES

In all the Nordic countries effort has been done to test both the questionnaire on human health and comfort and the Excel-sheet for environmental indicators. These tools have proved to be easy to work with and are practical tools to collect information from the users of buildings. The tools can be used for both existing buildings and buildings under construction and will therefore be important in finding the environmental burdens and benchmark them between the different Nordic countries This may be difficult due to of different building methods and building codes in the Nordic countries. The work with questionnaires is time consuming, but is often the only way to collect necessary information to base a strong and reasonable opinion

on. To interpret the results from the questionnaires can be a difficult task, but to use them together with the Excel-sheet is easy and an excellent choice.

7 DISCUSSION

Results from this Nordic project are seemingly useable in practical work estimating the environmental burdens from buildings and building management. By comparing trends of environmental indicators on a time scale one should be able to measure results from the companies' efforts to improve and decrease environmental burdens from their activities. A system of generally accepted environmental indicators to be used in building construction and building management will increase the possibilities for the property owners to compete with environmental arguments and demands. Implementing the use of environmental indicators among property owners will therefore be of great interest.

8 CONCLUSIONS

In this joint project of the five Nordic countries, which has been carried out over a period of three years, the main conclusions are:

- A group of environmental indicators has been developed in the areas of human health and comfort, resources, external environment, waste, chemicals and environmental policy.
- These environmental indicators will help the companies to demonstrate environmental trends and help them to measure results from measurements to minimize environmental burden from the property sector.
- Work has been carried out to find and demonstrate reference figures on key values for different building types.
- Implementation of environmental indicators will be a challenge in the near future.

9 ACKNOWLEDGEMENT

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Environmental assessment of renovation projects

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1. INTRODUCTION

There is a growing demand for taking environmental impacts into consideration in renovation projects, both because the environmental impact from operation and renovation of buildings is considerable, and because the long service life of buildings implies that the existing building stock will dominate the total building stock for many years. Operation and management of existing buildings are therefore key issues for the efforts to reduce environmental impacts related to the building sector.

Most literature and guidelines on LCA describe assessment of new products. This is also the case for literature on the use of LCA for buildings, e.g. the SETAC report on the use of LCA within the building sector (Kotaji 2001). How to use life cycle assessments as decision support for refurbishment and retrofitting of buildings should be further discussed. Preliminary conclusions on the considerations needed are shortly referred here. Furthermore, results from preliminary environmental assessments of renovation projects are presented.

To facilitate environmental assessment of buildings and building elements LCA tools have been developed, e.g. the Danish BEAT tool (Petersen 2000), first of all focused on environmental assessment of new buildings. For the use of these LCA tools in renovation projects, System boundaries need to be clarified, and supplementary facilities are needed that represent renovation measures in the LCA tools.

The paper is based on a number of projects involving BEAT. A European project INVESTIMMO focuses on the inclusion of a number of criteria in a decision tool for owners of residential buildings. Another project focuses on the Danish procedure for subsidised renovation projects. Finally two projects have comprised environmental assessments of a number of energy saving measures and of traditional renovation measures as well as environmental assessment of renovation compared with a new building.

ENVIRONMENTAL IMPACT

In the Danish action plan for sustainable development in the Danish building and construction industries (Product Panel 2001), priority is given to energy consumption, consumption of materials, waste prevention, and consumption of hazardous and environmentally harmful substances. In addition impacts are also mentioned that concern water consumption, emissions to soil and water, noise and vibrations as well as indoor environmental conditions and conditions relating to health and safety at work.

Energy consumption for heating one square metre of residential building in Denmark is estimated to be 200 - 800 MJ/m^2 depending on the age and size of the building. The total energy consumption for a new building is approximately 2 - 4 GJ/m^2 and for maintenance and renovations within a service life of 100 years approximately 1.5 GJ/m^2. Therefore, the consumption of energy for operation, especially for heating (including energy source), ventilating and cooling are the most important factors to consider regarding the energy consumption of existing residential buildings.

The type and amount of materials in renovation works do have a strong influence on the total environmental impact connected with these works, though the total amount of materials used per year for maintenance and renovation of existing buildings is small compared with the total amount of materials used per year for new buildings. This is because the consumption of materials beside gravel, concrete and clay bricks are of the same magnitude for existing buildings as for new buildings (Olsen 1993). The amount of building waste produced in Denmark per year is approximately 3 million tonne, compared with the input of building materials of close to 9 million tonne. Approximately 75% of the building waste are related to renovation and demolition of buildings.

Until now recognised examples of harmful substances in building products, which have been used in Denmark, that can affect human health and environmental health are: sealants, paints, adhesives, impregnated wood, plastics and metals. Beside, many existing buildings do contain harmful substances, either because they were allowed, when the building was constructed (e.g. asbestos and PBC) or renovated on an earlier occasion, or because former use of the building has contaminated the building.

Environmental indicators

The plan is to use the same set of environmental indicators for the life cycle of renovation works as for the energy consumption for heating etc, so that the total environmental impact for alternative renovation scenarios can be presented.

The environmental effects used as indicators in the environmental module for INVESTIMMO should be effects that are generally accepted and often used, and effects for which reliable and complete environmental data are usually available. Therefore the use of the following environmental effects as indicators is proposed:

- Global warming potential (GWP)
- Ozone depletion potential (ODP)
- Acidification potential
- Nutrient enrichment potential
- Photochemical ozone formation potential (POCP)
- Resources (optionally divided into fuels and metals)
- Bulk waste
- Slag and ashes

It will be considered to include assessments of water consumption and household waste and maybe also impacts related to local and indoor environment.

The tool will also include aggregation of the environmental effects into one single environmental indicator. This aggregation will be based on the use of weighting factors chosen nationally or by the users of INVESTIMMO.

SYSTEM

The environmental impact related to the life cycle of buildings are related both to temporary interventions like construction, renovation and demolition and to continuous efforts regarding operation and maintenance before and after interventions like refurbishment and retrofitting. Therefore the environmental impact related to existing buildings first of all depends on:

- Operation and maintenance before and after renovation
- Production and waste management related to renovation works
- Service life for the building as a whole and for the individual building elements

For LCA tools to be used in renovation projects clarification is needed regarding system boundaries and service life. It will be argued that environmental assessment of renovation projects first of all have to focus on operation, the choice of new building elements (refurbishment and retrofit measures) and service life expectations.

System boundaries

One of the main ideas of life cycle assessments is to analyse the whole life cycle of all components of a product. But for comparative assessments, processes can be omitted that are included in all the alternatives. For renovation projects, distinctions can be made between:

- Existing building elements that are not (or to a very limited degree) affected by any of the considered renovation alternatives; foundations and load-bearing walls for example can often be omitted, because they are included in all alternatives.
- Existing building elements that are removed from the building in one or more alternatives normally does not have to be included, see comments below.
- New, supplementary or replacements of building elements like glazing of balconies, supplementary heat insulation and replacement of roof has to be included[1].

Existing building elements, which are removed from the building, will normally have had such a long service life that it can be argued that the impacts related to the removal and waste management can be allocated to the service life so far and therefore will not differ between different alternatives. Looking at removed building elements, which can still be argued to be useful, and for which the service life so far has been short compared with the expected service life, it can be argued to allocate part of the impacts related as well to the production and construction as to removal and waste management to the removed element. This is not easy to do, because the existing building then has to be represented in BEAT.

Service life

The service life of buildings and building elements do have a strong influence on the environmental impact from the life cycle of the materials incorporated in the building. This is because this impact primarily is related to production and waste management, and because the impact will be calculated per year and added to the impact related to operation.

Moreover, further implications of the long service life for buildings and building elements need to be discussed. A difficult aspect is related to the definition of the alternative scenarios to be comparatively assessed. If the expected "renovation service life"[2] for the compared alternatives is very different, then a comparative life cycle assessment should include the same period of time for all the alternatives being compared. For alternative scenarios that include no action now, but which anticipate substantial renovation works within a short time

[1] Incl. new elements anticipated to be included in the building within a shorter time horizon.
[2] The time expected to go before the next comprehensive renovation is needed

horizon, these works, e.g. described in plan for maintenance and modernisation, has to be defined and included in the environmental assessment.

The service life and the end of life of a building or building element is not a matter of technical lifetime only, but it is also related to a number of other criteria such as functional, technical, economic, aesthetic, ecological and contextual criteria. But it is also important to state that for a number of building elements the technical criterion is crucial, and therefore also the degree to which these elements are maintained.

TOOL

In two projects that included environmental aspects in the decision-making process for renovation projects, efforts were made to facilitate the use of environmental assessment based on the use of the LCA tool BEAT (Petersen 2000), which is based on the Danish EDIP method (Wenzel 1998).

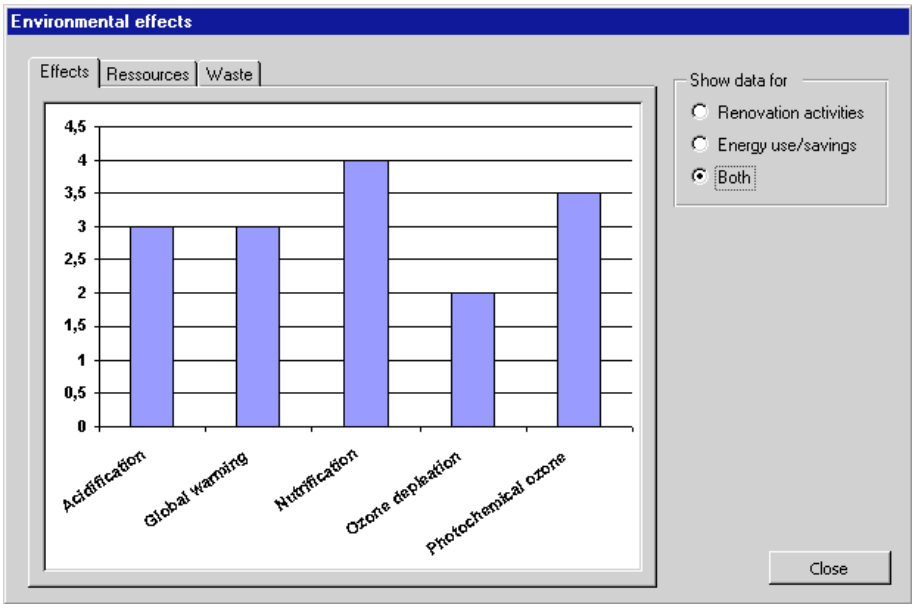

Figure 2. Example of how environmental effects could be presented in the environmental module in INVESTIMMO (screenshot from first prototype).

INVESTIMMO already includes modules for calculation of energy for operation (heating, cooling and lighting) and a database of typical renovation works. These renovation works are now being further specified and represented in BEAT for calculation of the environmental indicators. These indicator values will then be exported to INVESTIMMO, including indicator values for a number of energy sources for operation of the building. This means that INVESTIMMO can be used without using BEAT, which only has to be used for updating and for national adaptation. Facilities for weighting of indicators will also be included.

In the Danish project the intention is to represent typical renovation works in BEAT as macro-elements related to a Danish scheme for subsidised renovation projects. This means that the environmental assessment can be seen as a supplement to economic and other assessments.

RESULTS

Two Danish projects have comprised environmental assessment of a number of energy saving measures and traditional renovation measures (Petersen 2001), and environmental assessment of renovation compared with a new building (Hansen 2001). Later assessments of a number of renovation works will be made in INVESTIMMO.

The environmental assessment of energy saving measures shows that the energy consumption for production of these measures are of minor importance compared with the energy savings obtained during operation. But for other environmental issues, the impact related to the consumption of materials is of greater importance than the energy consumption for operation.
The environmental assessment of traditional renovation measures related to the addition of new kitchens and new bathrooms in older residential buildings shows significant differences with regard to environmental impacts. The assessment shows that metals are responsible for a large part of the environmental impacts related to the consumption of materials, but also gypsum boards and wood products contribute significantly.

The comparative environmental assessment of a typical Danish renovation project for an older residential building and a new building shows lower energy consumption and lower CO2 emissions than the renovation example, regardless of life cycle and heat source variations. The simple "pay-back" for CO2 emissions at demolition and new building, instead of renovation, is 25-30 years. The importance of significant changes to a number of selected preconditions and parameters were discusses. Based on the results, the most important parameters seem to be:

- Energy consumption and emissions related to building elements for new buildings
- Increase of thermal insulation for renovated buildings
- Energy consumption and emissions related to heat supply
- Expected service life is different for renovated and new buildings

Considerable changes will have to be made before the difference between new building and renovation of older residential buildings is equalised or favours renovation as long as only energy consumption and related emissions are in focus.

CONCLUSIONS

The consumption of energy during operation of the building is a key issue for the environmental impact of existing buildings, also regarding upgrading potentials. But also the consumption of materials for renovation and maintenance is of importance, because the materials used are often energy consuming and may include materials that may be scarce or include the use of harmful substances.

Renovation measures taken to reduce energy consumption during operation will reduce the environmental impact. Renovation measures that aim to provide greater comfort or new user facilities may heighten the environmental impact related to use, operation and maintenance. The rehabilitation and retrofitting of existing buildings can be so expensive and the obtainable reduction of energy consumption for operation so limited that demolition and building a new building can be the best choice, also from an environmental point of view.

The environmental assessment of renovation projects first of all to focus on operation, the choice of new building elements (refurbishment and retrofit measures) and service life, but normally does not focus on the existing building elements. Representation of refurbishment and retrofit works in LCA tools like BEAT can therefor facilitate the inclusion of

environmental aspects in decisions concerning management and renovation of existing buildings.

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4. Université de Genève (CUEH), Geneva, Switzerland
5. ESTIA sàrl (ESTIA), Lausanne, Switzerland
6. Fraunhofer Institut für Bauphysik (IBP), Holzkirchen, Germany
7. Verband bayerischer Wohnungsunternehmen (VdW), Munich, Germany
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9. Environment Park (ENVIPARK), Torino, Italia
10. National Observatory of Athens (NOA), Palaia Penteli,Greece
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A Danish method for environmental declaration and classification of buildings

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1. INTRODUCTION

In collaboration with the companies RAMBØLL and RH ARKITEKTER and with support from the then Danish Ministry of Housing and Urban Affairs, Danish Building and Urban Research has completed the first phase of a project with the purpose of elaborating a method of practical use for environmental declaration and classification of buildings. This paper describes the first phase of the project. In this phase it was decided what indicators should be included in the declaration, and a reference basis for assessment of these indicators was established.

In the second phase of the project, expected to start in 2002, the method will be tested in practice by applying it to 3 to 5 buildings during construction, both office and domestic buildings.

2. ENVIRONMENTALLY FRIENDLY BUILDING DESIGN

To ensure environmentally friendly building design it is necessary to:

- Set up environmental objectives at the planning stage.
- Make the right choice between alternative constructions, products and processes at the design stage.
- Document that when the building is finished it can fulfil the environmental objectives set up in the building programme.

2.1 Environmental objectives

Setting up environmental objectives is done on the basis of environmental indicators relevant for buildings. An environmental indicator is a measurable factor, which indicates one or more environmental effects. Environmental objectives should be set up for each indicator wanted. But to be able to set up objectives reference values for comparison are needed, i.e. of a "normal" or "ideal" building.

2.2 Environmentally friendly design

To fulfil the environmental objectives is a challenge to the designing architects and engineers. It means that they have to make the right decisions related to the construction, products and materials of the building. Environmentally friendly design also includes a planning of the

operational phase of the building regarding resource management and maintenance which have great influence on environmental impacts in the operational phase.

2.3 Documentation of environmental qualities

When a building has been designed, documentation of its environmental qualities and fulfilment of the environmental objectives is needed. Some qualities can not be finally documented until the building is in operation. For this purpose it is essential that an environmental accounting system for the building is planned and initiated.

2.4 Environmental assessment

Environmental assessment of building products, building elements and buildings is the basis for environmental objectives, environmentally friendly design and documented environmental qualities. Danish Building and Urban Research has developed the computer programme BEAT 2001 for environmental assessment of buildings. This tool is for inventory and assessment of environmental impacts related to production, operation and demolition of buildings.

3. ENVIRONMENTAL DECLARATION AND CLASSIFICATION

3.1 Environmental declaration

Environmental declaration of a building is a description of the actual status of the building for each chosen environmental indicator compared with a reference value, in this case a typical modern office building. In some cases the description can be limited to a single number, and in other cases a more comprehensive description is necessary.

3.2 Environmental classification

Environmental classification means categorizing the actual building in one of three environmental classes defined by a classification of each indicator. Some of the indicators are weighted and added to a final result with seven indicators.

In Figure 1 a graphic representation of the seven indicators and three environmental classes are shown.

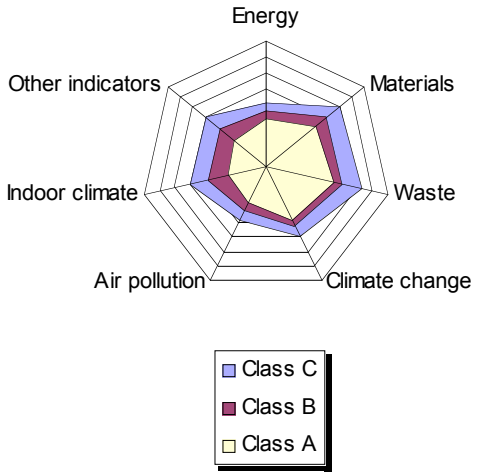

Figure 1 On each of the 7 axes the score of the actual indicator can be set and the classification can be seen. The best classification is closest to the centre of the diagram, i.e. the lower the score the better the classification. To obtain a classification A, all scores must be inside the white figure in the middle.

3.3. Environmental indicators

A number of environmental indicators selected are obviously essential and can be invented and evaluated quantitatively by using the computer programme BEAT 2001. These are:

- Energy consumption
- Material consumption
- Waste (volume waste, slag and ashes and hazardous waste)
- Climate impact (global warming potential and stratospheric ozone depletion potential)
- Air pollution (acidification and photochemical ozone formation).

Environmental indicators concerning indoor climate are essential but difficult to handle in a declaration process because they cannot be quantified and added. They are divided into four groups each of which include 4 or 5 indicators. Through a point system they are added to one overall indoor climate indicator.

The four groups are:

- Air quality
- Thermal climate
- Daylight, outlook, artificial lightning
- Noise and acoustics.

Furthermore, a number of "other indicators" are included. Other indicators are added to one indicator by a point system. Other indicators are:

- Undesired chemicals
- Water consumption
- Building operation
- Location of the building
- Personal choice (open for new indicators found essential).

Indicators of the working environment, land use, architecture and flexibility of the building have been discussed but are not included, primarily because useable evaluation methods are not available at present.

3.4 Indicator data sheets

Figure 2 shows extracts of sheets comprising and explaining declaration and classification criteria. They perform the basis for the declaration and classification of each indicator. Three last columns give criteria for classifying a building in class A, B or C, respectively.

Indicators calculated with BEAT

Values in person-equivalents pr. m^2 pr. year (PE/m^2/year) multiplicated by 100,000

Indicator	*Purpose*	*Concretising*	*Reference building*	*Class C*	*Class B*	*Class A*
Energy consumption	Reduce fuel consumption for energy production	Life cycle consumption calculated with BEAT and BV98	20	18	16	14
Consumption of materials	Reduce consumption of raw materials for production of building products	Life cycle consumption of selected raw materials calculated with BEAT	20	18	16	14

Indoor climate, air quality

Indicator	*Purpose*	*Concretising*	*Reference building*	*Class C*	*Class B*	*Class A*
Emission	Reduce emission from building materials to the indoor climate.	Indoor labelled (or similarly documented) building materials should be used for internal surfaces in following extent:	Existing regulations met.	Min. floor covering. 6 points.	All surfaces without specification of time value. 4 points.	All surfaces with the lowest possible time values. 2 points.
Dust	Reduction of dust by choice of building materials and cleaning and maintenance.	Not fleecy, not dirt hiding, cleaning friendly building materials, accessible surfaces, sufficient and right cleaning and maintenance.	Existing regulations met.	Cleaning friendly materials. 6 points.	Cleaning friendly materials, a few not accessible surfaces. 4 points.	Cleaning friendly and durable materials, no not accessible surfaces, program for cleaning and maintenance. 2 points.

Other indicators

Indicator	*Purpose*	*Concretising*	*Reference building*	*Class C*	*Class B*	*Class A*
Undesired chemicals	Reduce the content of undesired chemicals in building products.	Producers must work out safety sheets for chemical products	Existing regulations met.	A procedure for collection of safety sheets for the chemical products used have been worked out. 20 points.	A system for handling the safety sheets has been worked out. 15 points.	The chemicals have been prioritised and actions to avoid them have been done and are documented. 10 points.
Water consumption	Reduce consumption of clean water from the underground.	Initiatives to reduce consumption in the use phase.	Existing regulations met.	Water saving installations are used in the whole building. 20 points.	As C + surface water will be seepaged in the near surroundings and/or rainwater will be used for toilets and laundry. 15 points.	As B + use of grey wastewater and/or local cleaning of wastewater root zone system? 10 points.

Figure 2 Extract of indicator data sheets with declaration and classification criteria.

4. FURTHER WORK

The system and the criteria of declaration and classification is based on research work giving parties of the building sector possibilities of commenting and discussing the results with the participants of the project. However, testing the system was possible on one building only. Therefore a phase 2 of the project has been planned to test the system in practice on 5 buildings, and to be able to make a complete set of reference values for the declaration and classification.

In the future the system might be used as a basis for establishing a voluntary declaration method in co-operation with the parties of the building sector. Figure 3 shows alternative possibilities for establishing an environmental declaration system for buildings.

System	Who perform the declaration
Consultant system with authorization:	Architects and engineers who have designed the building
Consultant system with external audit:	Architects and engineers who have designed the building audited by an impartial consultant firm.
External certification system:	An impartial consultant firm.

Figure 3 Alternative possibilities for establishing an environmental declaration system for buildings.

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Environmental activities in a Danish municipality

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1. INTRODUCTION

Since 1996 Gladsaxe Municipality has worked on an environmental plan that comprises a superior strategy for the environmental effort.

2. ENVIRONMENTAL STRATEGY FOR GLADSAXE MUNICIPALITY

The municipality constantly wants to work on environmental improvement by minimising the resource consumption and reduction of pollution. Environmental improvements imply an active effort from all parts – the municipality administration, citizens, private households, corporations, companies, etc.

3. GENERAL ENVIRONMENTAL ISSUES

The City Council has focused on 10 major issues for a sustainable development:

1. Local Agenda 21
2. Environmental management in own companies
3. EU's environmental certificate – EMAS
4. Environmental management in companies in general
5. Green accounts
6. Green procurement and policy
7. Ecological food in the institutions
8. Environmental design in specific projects
9. Cleaning of polluted areas
10. Increased level of groundwater.

3.1 Local agenda 21

A plan for Local Agenda 21 has been worked out for the period 2001 - 2004. The plan describes environmental activities to be implemented by Gladsaxe Municipality in the years to come. See chapter 6.2.

3.2 Consumption development in institutions

Objectives have been set up for the consumption of electricity, water and heat per person and per m² building.

3.3 EMAS

EMAS has been implemented for the municipal road and park service.

3.4 Companies in general

Within the means of the municipality, it will help generating environmental activities in companies where possible.

3.5 Green accounts
The purpose of the green accounts in Gladsaxe Municipality is to create an overview of the environmental impact of the municipal activities. See chapter 6.1.

3.6 Procurement
All the institutions have a green procurement policy to some degree; environmentally friendly construction and specific projects for cleaning and groundwater are implemented.

4. ENVIRONMENTAL OBJECTIVES
Objectives have been set up by the municipality for the following areas:

- Water supply and water consumption
- Energy consumption and air pollution
- Noise pollution
- Product and material consumption
- Wastewater specially regarding lakes and other recipients
- Soil and groundwater pollution
- Garbage and deposits
- Urban greenstructures
- Environmental work regarding companies.

The specific objectives and means are stated in the environmental plan.

5. ENVIRONMENTAL MANAGEMENT SYSTEM
The objectives are to reduce consumption of water, energy, material resources and products.

The means to meet the objectives are environmental management, green accounts and environmentally friendly procurement policy as the most important elements.

5.1 Development projects
Introducing a handbook for environmental management. Implementation of cleaner technology and environmental management in connection with environmental approvals and permissions for disposal of wastewater.

Applying EMAS to the municipal park division and help to implement EMAS in selected companies.

6. ENVIRONMENTAL REPORTING
Gladsaxe Municipality has produced a green account for its own environmental profile as a company and an Agenda 21 report.

6.1 Green account
The account gives an overview for the consumption of electricity, water and heat in municipal owned buildings, approximately 340,000 m² floor space.

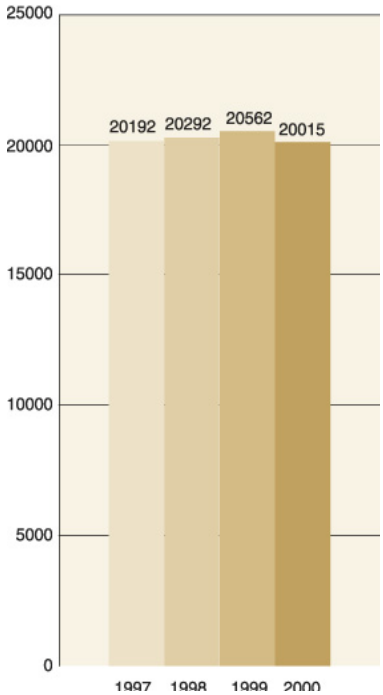
Besides this the supply system for water, sewer, remote heating and garbage is incorporated in the account.

The green account is the key to the environmental activities, and the account reflects the effect of the consumption reducing projects which has been implemented during the period 1997 – 2000. The green account inspires the institutions to further reducing of resources.

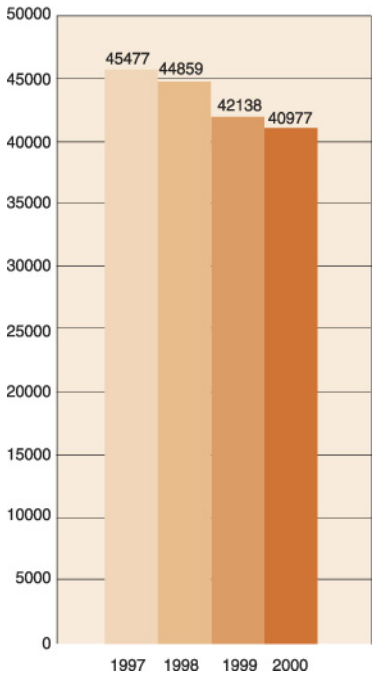
Several institutions are supported by the municipal environmental fond with the purpose of reducing consumption of electricity, water and heat. Besides the purpose is to decrease the environmental impact by applying environmental products and materials together with education within the field of environment.

Specific reductions of consumption is reported every year.

6.1.1 Consumption: Gladsaxe Municipality buildings.



Electricity consumption



Heating consumption

6.2 Agenda 21

Environmental activities has been implemented within following areas:

- Green Guide advising and organising citizens, unions and companies on environmental matters.
- Citizens can apply for support from the Agenda 21 fond for environmental projects.
- Environmentally friendly procurement of goods and services.
- Environmental council with members from housing associations, proprietors, companies, environmental organisations, unions, municipality and politicians.
- Tree planting foundation.
- Annual meetings with housing associations, proprietors, etc.
- Co-operation with external partners on specific projects, for instance improvement of traffic conditions, etc.
- Annual public arrangement concerning the municipal budget.

- Implementing cleaner technology, for instance by environmental and wastewater approvals, etc.
- Environmental newspaper with the last news about new local and national regulations and laws.
- Improvement of worn-down industrial areas.
- Cleaning of polluted soil.
- Co-operation on environmental matters with other municipalities and external partners
- Environmental activities also of theoretic character on institutions and schools.
- Urban ecological centre with lecturing facilities.
- Upgrading of libraries on environmental matters.
- Water supply and groundwater in focus taking notice of pesticides and preventing pollution of water resources.
- Minimizing hazardous materials in wastewater.
- Re-use of resources.
- Introducing energy management in public institutions.
- Implementing and planning for ecological traffic solutions, e.g. bicycle accessibility.
- Improving green areas.

7. ENVIRONMENTAL DESIGN

Prioritised environmental impacts as stated in the design programme for a new pre-school building at Enghavegård School.

Prioritized environmental impacts by design of the building					
Life cycle phase / **Environmental impact**	**Raw materials extraction and manu-facture**	**Production of building elements**	**Construction and renovation**	**Operation and main-tenance**	**Demolition and removal**
Energy consumption		e		E	e
Materials consumption		e	E		e
Water consumption				E	
Emissions to air		e	e	*	e
Emissions to ground		e		*	e
Emissions to water		e		*	e
Waste		e	E	E	E
Noise and vibrations			e		
Light				*	
Working environment		e	e	E	e
Indoor climate				E	
Changed physical surroundings				E	

E = highest priority
e = high priority
* implicit priority (under one of the other points).

Environmental impacts have been calculated using the computer tool BEAT 2001 made by the Danish Building and Urban Research.

7.1 Environmental objectives and means

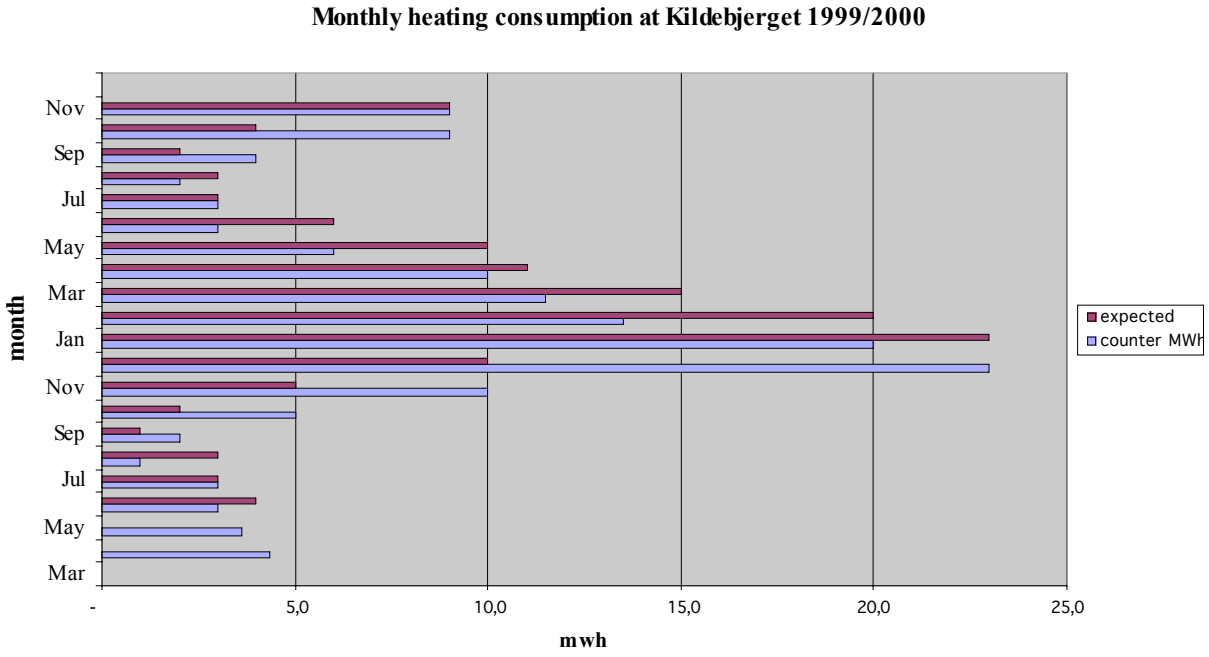
Environmental objectives, primary means and consequences for a new pre-school building at Enghavegård School.

Environmental objectives	Primary means	Effects
Raw materials extraction and manufacture. None		
Production of building elements **Energy and materials consumption, emissions to air, ground and water, waste and working environment.** Building elements produced with less consumption of resources (energy and materials) are preferred by choice between alternative products that are used in considerable amounts. Not renewable, not reusable materials should be substituted if possible. If technically and economically possible/responsible re-used materials should be used. Minimizing consumption of resources by good design is an objective.	During the design phase building products are investigated and chosen with the criteria that the producer has a certified environmental management system or can document environmental responsibility in the production. Locally produced building products with minimal energy consumption for transport are preferably chosen. During the design constructions are planned and chosen to avoid if possible non renewable and non reusable materials During the design possibilities for use of re-used materials are investigated. Use of sophisticated constructions with a minimum of resource consumption.	Demands to producers of building products to document that environmental matters have been in focus under production can be expected to have an effect as these demands are a visible expression of a user wish. Through environmentally friendly design routines are established for both Gladsaxe Community and external consultants to be used in the future.

8. SFO KILDEBJERGET

Forms and indicators worked out in a Nordic co-operation project have been tested at the after-school organisation SFO Kildebjerget, and detailed information has been collected in collaboration with the school management.

8.1 Heating consumption



9. CONCLUSION

Gladsaxe Municipality works to improving a sustainable development. The development must look after the existing generation without lowering the conditions for future generations' possibility of satisfying their needs.

The municipality must be in front showing the way, and all employees at all levels must be working together to reach the goals, thus inspiring society in general.

Gladsaxe Municipality will support local environmental activities in co-operation with citizens, companies etc. and continuously follow up on the environmental activities.

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Nordic Project environmental indicators for the building- and proprietor sector 1999 - 2001.

BEAT 2002 – An LCA based assessment tool for the building industry

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1. INTRODUCTION

BEAT 2002 (Building Environmental Assessment Tool) is an LCA based inventory and assessment tool developed at the Danish Building and Urban Research. It is targeted specifically at the building industry for environmental assessment of building products and buildings. At present the program is used by a number of Danish producers of building materials, consulting architects and engineers, technical schools and municipalities, as well as a number of technical schools and universities outside Denmark. BEAT was mainly developed for use during design of new buildings, where it can be used both early and later in the design phase, but it has also been successfully used for retrofitting. This paper describes the new facilities and improvements, that have been implemented since BEAT 2000 (the first version released in March 2000. Petersen, 1998).

2. NEW FACILITIES IN BEAT

A large number of facilities have been added or improved in BEAT. This paper will focus on:

- A simplified and quick method for defining buildings based on a few key data for use in the early design phase.
- Support for aggregated environmental effects and multiple assessment methods.
- Support for a simple economic assessment of the costs of the considered solutions.
- Support for multiple languages.

2.1 A simplified and quick method for defining buildings

The main purpose of a program like BEAT is to help building designers to design more environmentally friendly buildings. However, the opportunities for influencing and changing the design of a building is diminished quickly as the design process proceeds, and experience shows that most important decisions, which determines a building's environmental impacts, are made early in the design phase. Therefore the greatest environmental improvements can be achieved by performing environmental assessments as early in the design phase as possible, when it is still possible to make major changes.

Early in the design phase, detailed data about the building design are not available. The geometry of the building, and the amount and type of building materials and components are not yet known in detail, and this makes it difficult to define the building in BEAT and perform an environmental assessment. Naturally this also makes is difficult to identify the areas where the building's environmental performance can be improved.

Early in the design phase it can also be useful to test and compare a number of alternative design ideas to get an indication of which of these appear most environmentally promising.

This could be e.g. comparing different building geometries, construction principles or materials. But this is difficult because it can be very time-consuming to obtain and enter all the necessary data into BEAT for each alternative.

There was therefore a need for a simple and quick method, to define a new building in BEAT based on a few key data about the building. Such a method has therefore been implemented in BEAT. The idea is that the user enters a number of general data on the building, and then lets BEAT calculate the most likely amounts of building elements used in the building. The user must supply the following data:

- Type of building (detached house, terraced house, apartment house, office building, school or others).
- Estimated lifetime of the building.
- Geometry of the building (I, L, U or T shaped) as well as length and width of each section of the building.
- Number of floors above/below ground.
- Roof pitch (0, 14, 21, 27 or 45 degree angel).
- Number of windows in the building, and percentage of facade area covered by windows.
- Natural or mechanical ventilation.

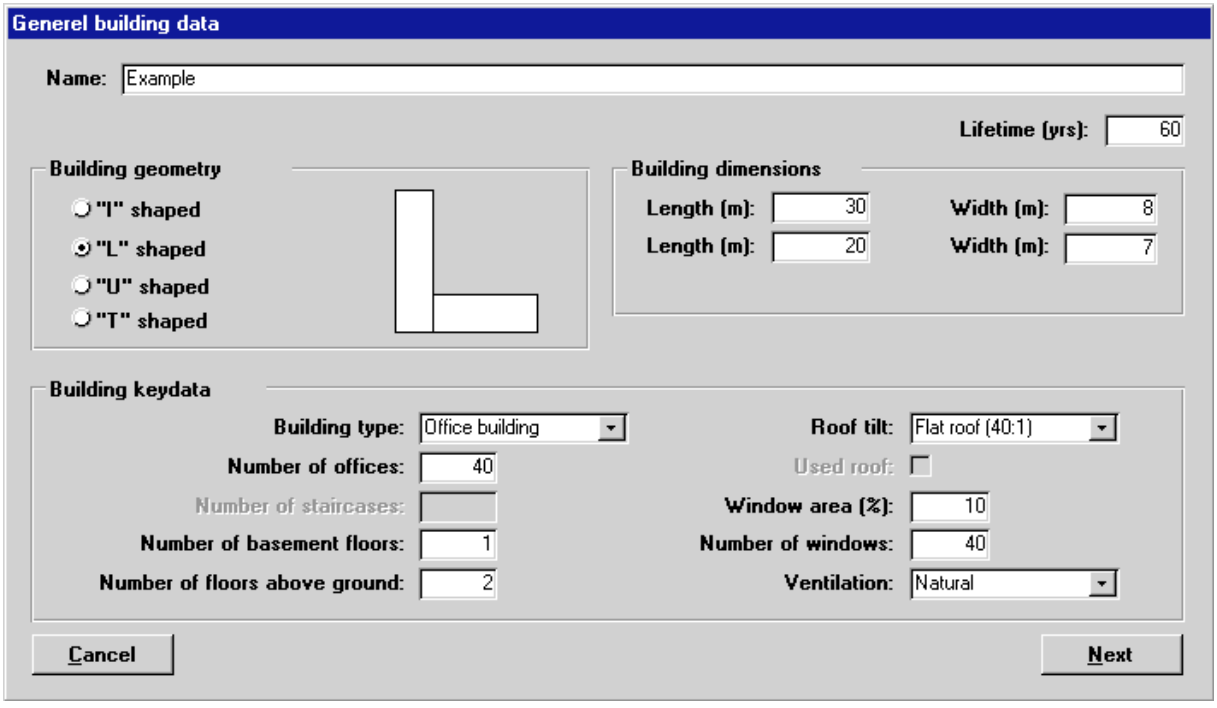

Figure 1 Quick method for defining buildings (window 1 of 3).

On this basis BEAT first calculates the area of each floor and the floor height. The user is then given the opportunity to adjust these figures in case e.g. not all floors are "full" floors or if some floors have different floor heights.

For each building element type in the building the user then selects a number of building elements (from the standard building elements in the database) and percentage each constitutes of the total. If e.g. three different types of foundation are used in the building,

these are selected (or if they can not be found in the database, the ones who comes closest are selected instead), and then the percentage is entered for each e.g. 20, 30 and 50 % of the foundation in the building. In the same way all other building elements, as well as the energy source(s) for heating and ventilation (if mechanical) are specified.

Based on these data, BEAT is now able to calculate/estimate the amount of each building element (and thereby also the amount of materials etc.) used in the building. Additionally, the amount of building elements replaced during maintenance of the building is calculated based on the individual lifetime of each building element. Finally the energy consumption for heating the building during its lifetime is calculated. This calculation is based on the regulations stipulated in the Danish Building Regulations (BR95), which specify a maximum energy consumption per square meter, depending on building type, floor area and number of floors. Likewise the energy consumption for ventilation is calculated by using the Danish Building Regulations minimum requirements for ventilation rates.

Naturally, some amounts can be calculated with good precision e.g. roof area, floor area, facade area, while others only can be estimated, e.g. partition wall area. In some cases it may therefore be necessary to manually change the amounts that BEAT has calculated, but usually they can be used as they are.

If the necessary key data are available, even a relative complex building can be defined and an environmental assessment performed in BEAT in less than one hour. Naturally, it is necessary to make a number of assumptions and simplifications because of the nature of the data used. Therefore the results may be subject to significant uncertainty. However, it is often sufficient to allow the user to identify and select the alternatives that are environmentally most promising.

Subsequently the data for the building can gradually be refined and adjusted in BEAT, as more and more design decisions are made, and BEAT can continuously be used to analyse and select e.g. the most optimal building elements, materials and energy sources. In this way BEAT can be used both for supporting the general design choices early in the design phase, and later for supporting the more detailed design choices.

2.2 Aggregated environmental effects and multiple assessment methods

In earlier versions of BEAT it was possible to use only one environmental assessment method. By default environmental effects, effect factors, normalising factors and weighting factors for the Danish EDIP method (Wenzel et al., 1998) were used. To use another method the user had to delete all the data related to the EDIP method, and to enter the corresponding data for another method. This was both time-consuming and difficult and therefore usually not possible in practice.

BEAT has therefore been expanded, so that it now is possible to have any number of environmental assessment methods, and just select which one to use when the results of an environmental assessment are displayed. The EDIP method performs its calculations for emissions and raw materials using the following formulas:

$$Environmental\ effect = \frac{weighting\ \ factor}{normalizing\ \ factor} \cdot \sum emission \cdot effect\ \ factor$$

$$Environmental\ effect = \sum raw\ material \cdot \frac{weighting\ \ factor}{normalizing\ \ factor}$$

As can be seen, the environmental effects (from emissions) are calculated by multiplying the amount of emissions that contribute to the environmental effect with an effect factor. In this way the amounts are converted to equivalents, e.g. CO_2 equivalents, that can be summed up into one figure. The sum is then divided by a normalising factor and multiplied by a weighting factor. For raw materials the calculations are almost the same, except that the effect factor is replaced with individual normalising and weighting factors.

Other environmental assessment methods must be able to fit into this "framework" (if necessary some of the factors can be set to one). Any environmental assessment method, which fulfils this requirement, can be entered into BEAT.

Many environmental assessment methods, including the EDIP method, results in a relatively complex environmental profile with many different environmental effects which may be difficult to understand and interpret. Many users have therefore asked for a way to further aggregate the environmental effects to a smaller number of indicators – maybe even to one figure (as can been done in the Dutch Equ-Quantum tool, IVAM, 1998).

Therefore such a method has been implemented in BEAT. Any number of aggregation methods can be entered for each environmental assessment method. The user can enter one or more aggregate effects and specify what environmental effects are included. Additionally the user supplies a weighting factor for each environmental effect. The aggregate effects are then calculated using the following formula:

$$Aggregate\ environmental\ effect = \sum environmental\ effect \cdot weighting\ \ factor$$

As can be seen, the aggregated environmental effects are calculated by multiplying each environmental effect by a weighting factor and then summing the results. Naturally, facilities have been implemented to view the aggregate effects graphically the same way as the environmental effects. It is therefore possible to se e.g. the relative contribution of each building element in a building to each aggregated effect.

2.3 Support for a simple economic evaluation

When optimising the environmental performance of a building, usually the economical consequences have to be considered also. A solution, which from an environmental point of view seems good, may be too expensive and cannot be used. Therefore a simple method has been implemented that allows the user to get an indication of construction, maintenance and operation costs of a building. In this way the user will be able to compare different environmental alternatives and immediately form an idea of the economic consequences. The method in the current version of BEAT is very crude, but it will be refined in a future versions if the users find the method useful.

BEAT is primarily a program for performing environmental assessments, and is not intended to replace tools dedicated to perform life cycle cost analysis. The implemented method for handling costs is therefore very limited. It does not perform a full life cycle cost analysis, but calculates only the costs associated with that which differentiates the solutions under consideration. This makes the economic calculations much simpler.

If the user is considering two buildings, constructed using e.g. different building elements (i.e. different materials), it is only necessary to calculate the difference in costs for the selected building elements, including differences in maintenance arising from different lifetimes. It is also necessary to calculate the differences in costs for energy if the buildings use different energy sources for heating and ventilation, or if the energy requirements of the buildings are different (if the building elements have different U-values). All other expenses will basically be the same for the two alternatives, and therefore need not be calculated in order to compare the two buildings.

To make this possible the user now can enter the price of each energy source (price per MJ), and the price of each building element (e.g. price per m or m^2) into BEAT's database. Based on these prices BEAT can easily calculated the relevant costs for construction (the building elements), maintenance (replacement of building elements) and operation (energy for heating and ventilation). In this way economic considerations can be incorporated into the environmental assessment. Naturally, as the method is very crude, the results must be seen more as an indication than as a precise figure. However, it should be sufficient to allow the user to identify both the very cheap and the very expensive solutions, and thereby ensure that the selected alternative can be realised without too much extra expenditure.

2.4 Multiple languages

BEAT was not originally designed for use outside Denmark. However, interest in the program outside Denmark has been so big that it was decided to make an English version also. During the preparation it was realised that it instead of making a Danish and an English version of BEAT, it was possible to implement a method that allowed BEAT to switch effortlessly between any number of languages. For each new language, a column just has to be added to five tables in BEAT and the translated words and sentences have to be entered. At present the user can select between four languages: Danish, English, German and Spanish, and more are expected to be added later. This way only one version of BEAT has to be maintained and supported, regardless of the number of languages.

However, it should be noted that only the user interface changes language this way. The help file and documentation for the program are too large to translate and maintain for more than one or two languages. Therefore this part is only available in Danish and English. This is also the case for the database containing data for energy sources, means of transport, products and building elements. The Danish version of the help file and the database are automatically used by BEAT when the user selects a Nordic language. Otherwise the English version is used.

3. CONCLUSION

With the above mentioned improvements and the many other changes and improvements implemented in this version of BEAT, DBUR feels that we have a tool for environmental assessment which is useful during all design phases of a building, and which can be used both by professionals and non-professionals. The program can also be used both by users who need a very detailed environmental assessment that requires expert knowledge to interpret, and by users who just need a more general and easy-to-understand environmental assessment of a building (or a building element, or a material). BEAT is now also very simple to change both regarding language and content making it easy to adapt for use in other countries.

The greatest problem of the current version of BEAT does not relate to the program itself, but to the database. The database in the current version contains data for a large number of

building materials and building elements. But it contains little or no data for building materials used in e.g. plumbing, electric installations and surfaces. DBUR is working on a project, which is expected to provide some of these data within a year or two, and will then release an updated database containing materials for typical plumbing solutions. Electric installations and surfaces may be added later.

BEAT will continue to be developed as users contact us with new ideas and suggestions. DBUR is already considering integrating BEAT with other programs. The first will probably be DBUR's program for analysing indoor climate and energy consumption in buildings (BSim2000). This will also automatically make it possible to import (some) CAD drawings directly into BEAT.

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Environmental assessment of energy efficient windows

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1. INTRODUCTION

In Denmark, about one third of the energy consumption is used in buildings, mainly for heating. Approximately one third of this energy is lost through windows. The Ministry of Energy and Environment has therefore supported a programme for product-related energy savings, which includes the development of an energy labelling of all types of windows as well as a campaign to market these windows. The project *Environmental Assessment of Energy Efficient Windows* is a part of this programme. The purpose of this project is:

- to co-ordinate existing methods for calculating the environmental loads from production, use and disposal of windows and to work out a common format (an environmental declaration sheet or a data sheet) to represent the data;
- to document differences in the quality of daylight for different types of glazings;
- to assess the total energy balances for different rooms when using "energy efficient" windows to show if cooling is necessary.

The article describes objective, method and results of environmental assessment of windows, the quality of daylight and the energy balances for different rooms.

2. ENVIRONMENTAL ASSESSMENT OF WINDOWS

2.1 Objective

The purpose of the environmental assessment is to co-ordinate methods for life cycle assessment with methods for energy-labelling of windows and report the results in a common format that indicates the most important loads and suggest possible improvements. Moreover, the purpose of this project coincides with the intentions of the product-related politics in progress in EU.

2.2 Methodology

The environmental assessment used the Danish LCA model, EDIP (Environmental Design of Industrial Products) and a computer tool with a related database, BEAT (Building Environmental Assessment) developed at the Danish Building and Urban Research (Petersen, 2002). The tool has implemented the Danish LCA model to perform life cycle assessment of buildings, building elements or construction products.

The LCA model includes an inventory for the total life cycle of a product followed by an impact assessment. In this case, all phases of the life cycle are considered from cradle to grave: the production of materials, manufacturing of a window, its maintenance, renovation, demolition and disposal of the materials including energy loss when using the window. The tool calculates environmental impacts by multiplying the results from the inventory with an effect factor for the concerned impacts. The impacts are normalised and weighted in accordance with the Danish LCA model. The energy loss is calculated in accordance with principles in the Danish energy-labelling system (www.energimarkning.dk):

$$E = 196.4 * g - 90.36 * U$$

E: Energy loss (kWh/ m^2/year).
g: Total transmittance of the window(%).
U: Transmission heat coefficient (W/m^2 K).

The Danish energy-labelling system is developed for residential buildings, and thus, the energy balances for institutions (e.g. school, offices, etc.) may use other methods.

2.3 Results

The results are communicated on an environmental declaration sheet for each window according to the Danish environmental declaration of building components (Hansen et al., 2000). The sheet includes:

- table of contents for all materials (greater > 2 weight %) and a list of the dangerous substances;
- environmental profile with five indicators;
- description of important processes;
- detailed table of environmental loads and a table of dangerous substances drawn from safety sheets for chemical products.

In the environmental profile the impacts are aggregated to five indicators, see Table 1. Impacts from production and use of dangerous substances are not included in the environmental profile because of insufficient data and models, and therefore they are only listed.

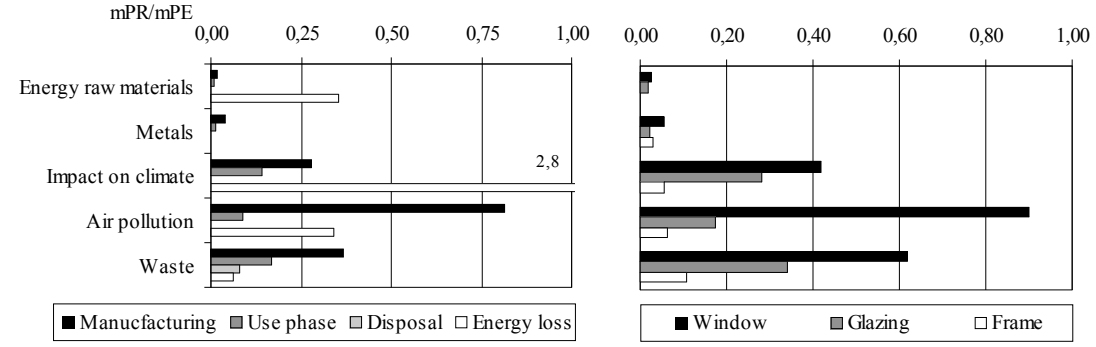
Table 1. Aggregated impacts used in this project and in the Danish environmental declaration for building components.

	Impacts	**Indicators**
Resources	Energy raw materials	Energy sources
	Materials (metals)	Materials
Global impacts	Global warming	Impact on climate
	Depletion of ozone layer	
Regional impacts	Acidification	Air pollution
	Photochemical oxidant formation	
Local impacts	Bulk waste	Waste
	Hazardous waste	

This project includes glazings with low e-coating and filled with Argon, no ordinary double glazing is included. The environmental profile for a wooden window is shown in Figure 1. The impacts from the energy loss dominate the profile. In this case, natural gas is used for heating the house with an energy efficiency of 90%. Figure 2 shows the environmental profile for the window excluding the energy loss. In this figure, the total impacts for the window are the sum of the impacts from the frame and glazing. Impacts from volatile organic compounds from the preservative are only included in air pollution from the window.

Different types of windows (size and constructions) have an influence on the environmental profile, see Figure 3. The "Dannebrog" type (with crossing window bars) has a greater energy loss than the other type leading to greater impacts relating to this energy loss. Infill gases like Argon and Krypton may reduce the energy loss, but as the manufacturing of Krypton is very

energy consuming, the impacts of the window with Krypton are bigger than the impacts with Argon, see Figure 4.



mPR: milli person reserve for energy raw materials and metals; mPE: milli person equivalent for the other mentioned impacts. Impacts are normalised by dividing the impacts with an average impact from 1 person per year in Denmark. Example: global warming potential is calculated per year of the window, $CO_{2\ eqv}$, and then divided with the total $CO_{2\ eqv}$ in Denmark per year per person giving global warming potential in person eqv.

Figure 1 (left) shows the environmental profile for a wooden window, one framed and 1.23 * 1.48 m with a double glazing (one low e-coating) and with Argon.

Figure 2 (right) shows the same window without impacts from energy loss, impacts related to frame, glazing and the total window.

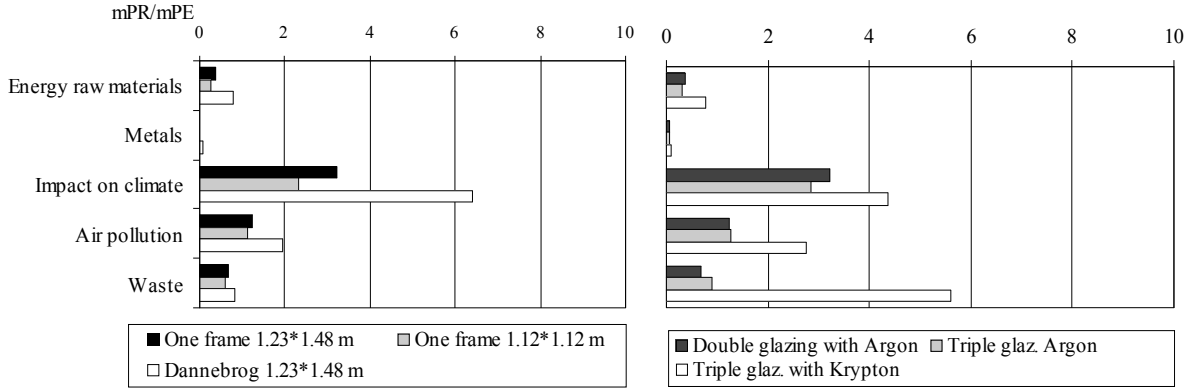


Figure 3 (left) shows the environmental profile of different types of windows.

Figure 4 (right) shows environmental profiles of windows (with double or triple glazing) filled with Argon or Krypton.

3. WINDOWS AND DAYLIGHT QUALITY

3.1 Objective

While window coatings greatly contribute to reduce heat losses or overheating through windows, they modify the intensity and colour of daylight and have an impact on the quality of the view through windows. Since providing daylighting and a view out are two of the main reasons for having windows in the first place, the programme *Windows* includes a study concerned with investigating the impact of energy-efficient (i.e. coated) windows on daylighting and the view out. Some of the objectives of this study are stated below:

- investigate the impact of window coatings on the perception of daylight quality and intensity and on the perception of the colours, texture and shape of objects in a room and appearance of the view out;
- verify whether the impact of window coatings on daylight quality is judged acceptable by people.

3.2 Methodology

This study was performed using two scale models (scale 1:7,5) of a real room measuring 3,5*6,0*3,0 m^3 (W*D*H) and having one window measuring 1,78*1,41 m^2 (W*H). Each scaled room contained a scaled table, a coloured picture, a black text on white background, a tomato, a piece of broccoli, a pine cone, a tennis ball, a key and a staple remover. The two scale models were placed behind the single clear glazing window of a north oriented office room. The north orientation and overcast sky conditions were chosen as they provide the most constant (intensity and colour) natural light.

The window of the scale models could be alternately fitted with double- or triple-pane windows with various types of low-emissivity and/or solar-protective coatings (Table 2). One of the scale models was used as a reference room and fitted with window B as it was the most neutral in colour due to the low iron glass. The other scale model (test room) was alternately fitted with one of the other windows (A, C-F).

Table 2. Coated windows studied (LT: Light transmittance, TST: Total solar transmittance).

Name	Type	Description	U value W/m^2K	LT %	TST %
A	2 pane	1 clear + 1 clear with low-e (soft) coating	1.12	79	63
B	2 pane	1 low iron + 1 clear with low-e (hard) coating	1.48	77	79
C	2 pane	1 clear + 1 clear with low-e (hard) coating	1.45	76	72
D	3 pane	1 cl. with low-e (soft) + 1 cl. + 1 cl. with low-e (soft)	0.46	70	46
E	2 pane	1 solar with low-e coating + 1 clear	1,12	62	40
F	2 pane	1 solar with low-e coating + 1 clear	1,07	50	26

Eighteen subjects (50% males) all aged under 45 years old and having a normal colour vision participated in the experiments. Each subject came to the laboratory three times. Each time, the subject was asked to first observe the conditions in the reference room and fill a two-page questionnaire based on seven-grade semantic scales. This questionnaire concerned the quality and intensity of daylight and the colour, texture and shape of objects in the room as well as the qualities of the weather and appearance of the scene viewed through the window. The subject was then asked to look into the test room and fill another questionnaire identical to the first one. The experimenter then changed the window of the test room and asked the subject to observe the conditions in this room and fill a third questionnaire in the same way as he/she had previously done. This last step was repeated one more time with a different window. This whole procedure was repeated the second and third time the subject visited the laboratory (see Dubois & Johnsen (2002) for more details). The following data was also recorded during the experiments: the interior work plane illuminance (lx), the exterior vertical illuminance on the north facade (lx), the interior vertical spectral irradiance behind the single clear glazing (W/nm) and the exterior global illuminance (lx).

3.3 Results

Although the statistical analysis of the results is not yet completed, a preliminary analysis indicates that the subjective evaluations were consistent from one session to another and from

one question to another. Moreover, the subjective evaluations were also approximately consistent with the light transmittance of the windows (see Figure 5) although it appears that the colour of the window had a significant influence on the subjective ratings. For example, Figure 5a (left) shows that window B was generally rated more positively (not tinted, clear and pleasant) than window A, which had a higher light transmittance but a less neutral colour (more green). The same may be observed in Figure 5b (right): the subjective ratings were slightly more positive (natural, not tinted) for window B than A despite a lower light transmittance. This figure also shows that window D and E were rated approximately the same for this question although window E had a lower light transmittance than window D. An examination of the CIEL*a*b* coordinates of window E revealed that this window's transmittance was slightly more yellowish than window D, which may have contributed to a more positive rating.

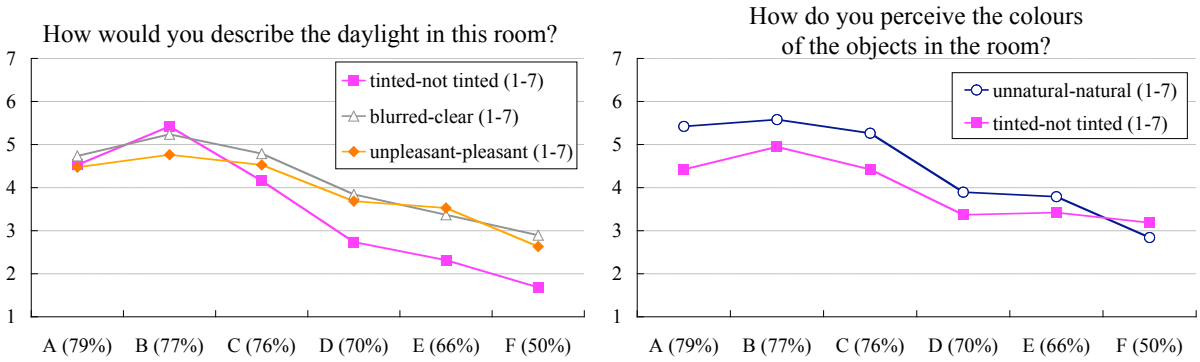


Figure 5. Average values of the subjective ratings (1-7) for two of the questions.

Although more fundamental research (in full-scale rooms, with more subjects exposed for a longer period of time) is needed, this study indicates that some window colours may be preferable than others. More detailed information about the impact of window colour on perception may be crucial for developing and selecting energy efficient windows in the future.

4. GLAZING TYPE AND OVERALL ENERGY CONSUMPTION

4.1 Introduction

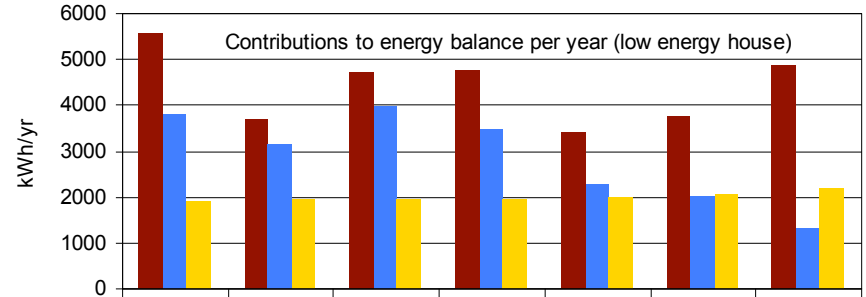
Most of the winter there is a heating demand in residential buildings, while in offices and institutional buildings there are changing demands between heating and cooling. Therefore the "energy performance" of the selected glazing type strongly depends on the type of building in which the glazing is used.

4.2 Methodology

The energy demands for heating and lighting (and cooling) were assessed by simulation with the software package BSim2000 developed at the Danish Building and Urban Research. Models of a house, an apartment, an office and a part of a school building were established as the basis for the simulations using typical constructions, systems, internal heating loads, as well as typical profiles of use. The glazing types compared are those listed in Table 2 (A-F) plus an traditional double glazing, called glazing O. The following sections describe the results for the house and the office building.

4.3 Results for residential buildings

As expected, the most significant differences in the energy consumption of the house due to the type of glazing are the energy need for heating. Figure 6 also shows the total solar transmission through the windows over the whole year. The solar contribution to the heating of the house is significant while the contribution to the lighting is modest, about 5% between glazing A and E. The figure shows that solar protecting glazing types (E and F) should normally not be used in residential buildings, since both the energy for heating and for lighting will increase compared with today's standard low-energy glazing (A).

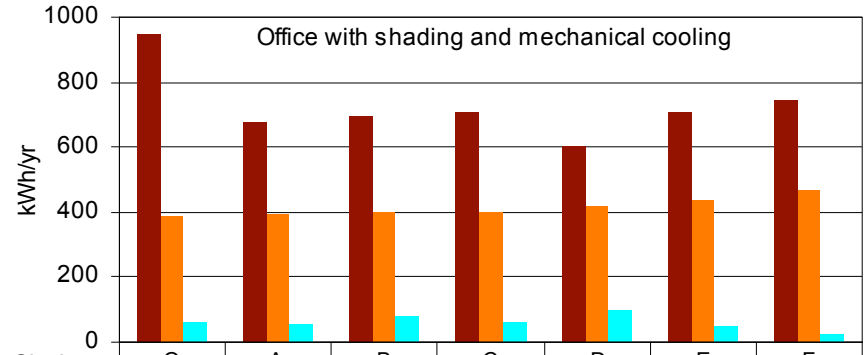


Glazing	O	A	B	C	D	E	F
Heating	5577	3694	4718	4745	3414	3751	4848
SolarRad	3816	3163	3967	3493	2285	2008	1305
Lighting	1927	1943	1956	1965	1994	2055	2201

Figure 6. Energy demand for heating and for lighting in a low energy house with different glazing types.

4.4 Results for offices

A single 20 m^2 office with similar rooms on four sides, a façade with two windows 1.23 x 1.48 and 7 different glazing types was modelled and simulated. The office was modelled with typical internal loads and patterns of use, and with mechanical ventilation and extra venting (window opening) when the indoor temperature exceeded 23,5 °C. The lighting has a daylight responsive 2-level control, and the office has mechanical ventilation with an air change rate of 3 ach/h. Furthermore, in order to achieve comparable thermal indoor conditions, a solar shading device and mechanical cooling were assumed to be controlled in order to keep standard Danish requirements for the operative temperature. According to these, the operative temperature must not exceed 26 °C more than 100 hours and 27 °C more than 25 hours of all working hours of the year.



Glazing	O	A	B	C	D	E	F
Heating	945	675	693	704	604	705	741
Lighting	389	392	400	401	416	436	467
Cooling	62	57	77	60	99	48	25

Figure 7. Energy demand for heating, lighting and mechanical cooling in a 20 m^2 office.

Figure 7 shows that when solar protective glazings are used the heating and lighting demands increase while the cooling demand decreases. The figure indicates that "environmental performance" of the glazing types can only be judged when the energy sources are known. In Denmark an "environmental factor" of 2.5-3 is often used when electrical energy is compared with heating energy. The result of using a weighting factor of 2.5 is shown in Figure 8.

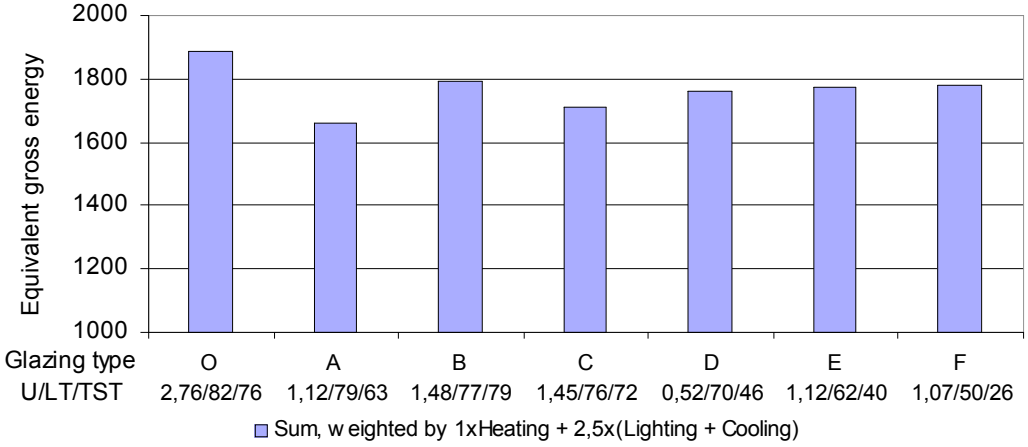


Figure 8. Weighted sum of energy consumption for heating, lighting and cooling influenced by the type of glazing being used in a 20 m^2 office.

Figure 8 indicates that the U-value is not decisive for the energy performance of the glazing, and the "standard" low-energy glazing (A) should normally be preferred for triple glazing with two low-emissivity coatings or solar protecting types. In the choice of glazing, the visual aspects, as mentioned in section 3, should be given high priority for the benefit of the users.

5. ACKNOWLEDGEMENTS

The project has received support from *Project Window*, a part of a programme for product-related energy saving activities, administered and financed by the Danish Energy Agency. The authors wish to thank for the support.

6. CONCLUSIONS

The environmental assessment has shown that it is possible to calculate indicators for some environmental impacts and it was not possible to calculate impacts from use of dangerous substances because of insufficient data and models. The results show:

- Impacts from energy loss dominate the environmental profile. Therefore the construction of window bars influences the environmental impacts
- The production of Krypton is energy consuming and, therefore, increases the environmental impacts of the window
- Improvements of the windows should be made by using materials improving the U- and g-values of the window without increasing energy consumption for manufacturing the materials
- A pilot study on daylight quality has indicated that the colour of the window may have a significant impact on occupants' perception of daylight and colour rendering

– Computer simulations with BSim2000 show that the type of glazing has little significance on the use of lighting in residential buildings while significant influence on the need for lighting and cooling in offices.

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Harmful substances in building waste in the future -Inventory and prediction of twelve substances

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1. INTRODUCTION

The industrial world continues to use large quantities of chemical substances in all types of products in order to enhance technical properties, extend a product's life etc. Some of these substances have already been shown to have an impact on the environment and/or human health. Therefore the authorities have made regulations or bans to counter these impacts. This article is based on a project that focuses on harmful substances used in buildings and building materials and that eventually end up in building waste. The Ministry of Environment and Energy has financed the project.

The main aim of the project was to investigate and predict the streams of harmful substances that may appear in building waste in the period 2001-2025. Furthermore the project included investigations of the needs and possibilities for the sorting, collection and disposal of the identified harmful substances. Based on the findings during the project recommendations were drawn up for the further development of collection systems, disposal methods and means of handling these harmful substances.

2. IDENTIFICATION OF HARMFUL SUBSTANCES AND CORRESPONDING DISPOSAL PATTERN

The following twelve harmful substances have been identified and investigated in this project:

- Lead
- Cadmium
- Mercury
- Nickel
- Chromium
- Copper
- Zinc
- Polychlorinated biphenyls (PCB)
- Chlorinated paraffins
- Chlorofluorocarbons (CFC)
- Hydrochlorofluorocarbons (HCFC) and hydrofluorocarbons (HFC)
- Sulphur hexafluoride

These substances were selected from a long list of undisireable substances. The selection was mainly based on toxicity (either on the environment or on human health) and the consumption of the substances. An inventory of the twelve substances was made, describing their application, consumption, toxicity and anticipated disposal processes for the waste. Table 1, below, shows an estimated disposal pattern of the twelve identified harmful substances divided onto building materials/components.

Substance	**Building components and/or materials**	**Disposal pattern**		
		Recycling	*Incineration*	*(Controlled) Landfill*
Lead	Roofs and tiles	90 %	5 %	5 %
	Electrical cables	50 %	10 %	40 %
Cadmium	Plastic (e.g. cable, pipes and plates etc.)	20 %	30 %	50 %
	Occurring with zinc	90 %	5 %	5 %
	Occurring with concrete	90 %	0 %	10 %
Mercury	Fluorescent tube	90 %	10 %	0 %
	Switches and relays (Electrical installations)	40 %	0 %	60 %
	Others (e.g. concrete)	90 %	0 %	10 %
Nickel	Stainless steel	90 %	5 %	5 %
	Surface treatment	80 %	10 %	10 %
Chromium	Stainless steel	90 %	5 %	5 %
	Others (e.g. painted surfaces)	0 %	95 %	5 %
Copper	Cables and wires:			
	- Permanent installations	30 %	20 %	50 %
	- Temporary installations	20 %	70 %	10 %
	Roofs, pipes etc.	95 %	5 %	0 %
	Screws, locks etc.	20 %	80 %	0 %
	Pigments and dyes	0 %	100 %	0 %
Zinc	Gutters/pipes and galvanised products	90 %	5 %	5 %
	Plastic (especially gutters and pipes)	20 %	60 %	20 %
PCB	Small capacitors	0 %	10 %	90 %
	Double-glazed windows (glue)	0 %	10 %	90 %
	Sealant (softener)	0 %	10 %	90 %
	Paint (pigments)	0 %	10 %	90 %
Chlorinated paraffins	Plastic (in general)	20 %	70 %	10 %
	Sealant (softener)	0 %	10 %	90 %
	Others (e.g. glue)	0 %	10 %	90 %
CFCs	Thermal insulation – PUR foam	0 %	90 %	10 %
	Other insulation materials	0 %	90 %	10 %
HCFCs and HCFs	Thermal insulation – PUR foam	0 %	90 %	10 %
	Foam for joints	0 %	90 %	10 %
Sulphur hexafloride	Soundproof windows	0 %	10 %	90 %

Table 1 Summary of identified building components and materials with harmful substances and outline of presumed disposal pattern for the identified building components and materials containing harmful substances

3. DESIGN OF MODEL FOR DISPOSAL

Based on data from the inventory and assumptions about the service life of the different building waste components and materials a model was developed to forecast the amounts of the substances that are expected to appear in the waste stream in the period 2001 to 2025. The model was applied to each substance and resulted in graphs showing the input of the substance in the building sector, its output to the waste stream and the accumulated amount over time.

3.1 Modelling

The forecast was based on the following operations:

Construction of 'Input curve':
For each of the twelve substances a number of building components and materials are identified. An input curve is constructed for each component or material based on the knowledge or assumptions about when the component/material was introduced and in which period it was used in the building industry. In order to obtain an overview of the particular substance the input curves for different components/materials for a particular substance are combined to make input curve.

Construction of 'Output curve':
For each building component or material an average life span has been estimated, which is used in the theoretical calculation of when the particular component and corresponding substance is predicted to appear in the waste stream. With the appointed life span (based on assumptions) the purpose was to take into account the fact that building components and materials are often replaced before the end of their technical life (owning to the buy and sale of buildings or the variations in trends etc.).

The 'Output curve' is produced by "shifting" and combining the input curves for the particular substance with the defined life spans of the components and materials:

Output amount in year (X)= Input amount in year (X – the average life span)

Thus the output amount for a window with an estimated average life span of 30 years is calculated as follows:

Output amount in 1999 = Input amount in (1999 - 30 years) = Input amount in 1969

As mentioned above the output curves for the identified buildings components and materials relating to a particular substance are combined (into one curve).

Construction of curve for the accumulated amount
Based on the input and output curves, explained above, one curve is constructed showing the total amount of the particular substance in a given year (see equation below):

$$Amount\ \ accumulated\ in\ year\ X = \sum_{Year=0}^{Year=X} Input\ amount - \sum_{Year=0}^{Year=X} Output\ amount$$

4. THE DISPOSAL MODEL USED ON PCB As AN EXAMPLE

The graph below shows the curves of the amounts (streams) of PCB in the building industry in the period from 1950 to 2025.

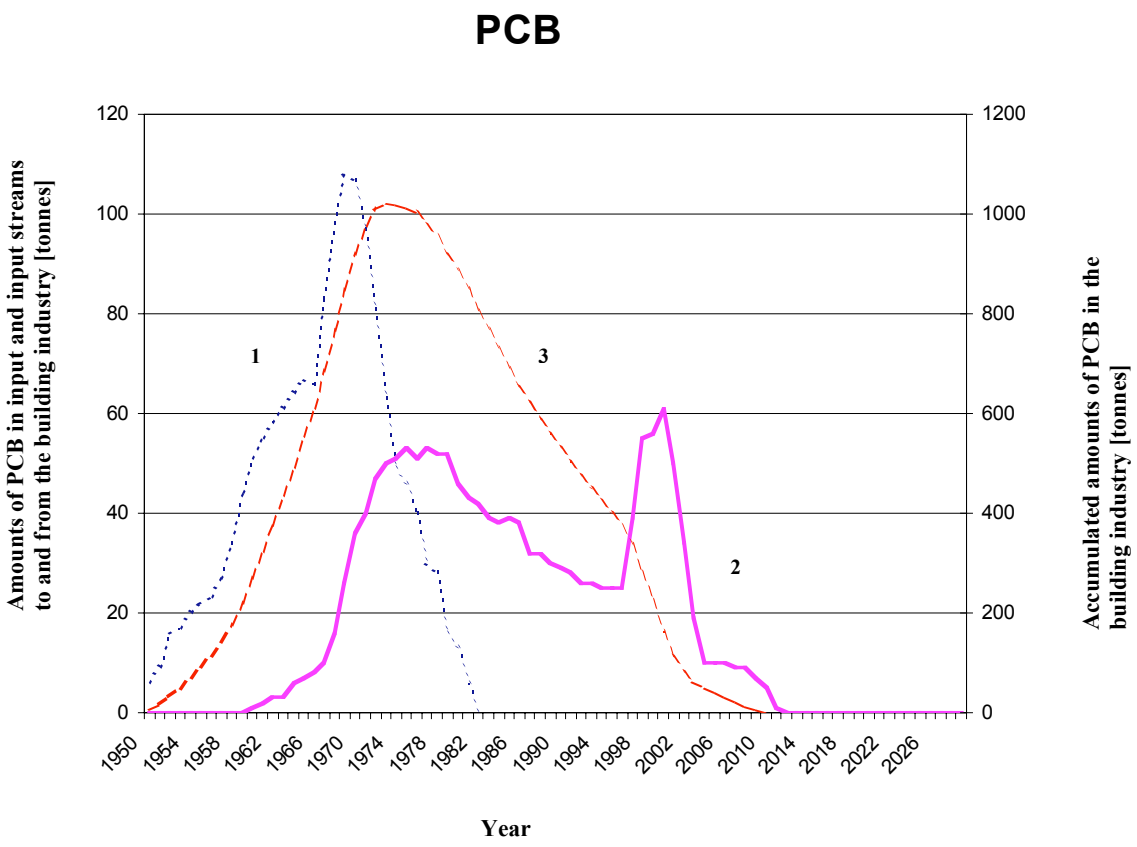

Figure 1 *Graphical illustration of the input, output and accumulated amounts of PCB in the period 1950-2025. Curve **1** = Input of PCB to the building industry (in tonnes), curve **2** = Output of PCB in the waste stream from the building industry (in tonnes) and curve **3** = Accumulated amount of PCB in the building industry (in tonnes).*

The data and information shown in Table 2 below was included in constructing the Figure above.

Primary components/materials and percentage distribution from 1950-1981		**Presumed life span [years]**	**Primary period of application**	
			From	**To**
Sealants	7 %	35	1950	1976
Double glazed windows (glue)	13 %	30	1967	1973
Small capacitors (lighting etc.)	21 %	10	1950	1981
Paint and plastic	19 %	10	1955	1973
Transformers and large capacitors	40 %	20	1950	1981

Table 2 *Presumed life spans and periods of application for the primary building components and materials containing PCB*

4.2 Future waste stream of PCB

It appears from Table 2 that the periods of application for components containing PCB in the building industry have been relatively limited. The maximum life span is approximately 30 years (for sealants and double glazed windows) and the periods are particularly short for paint, plastic and small capacitors.

As indicate above the designed model is based on presumed (but specific) life spans of the primary components and materials. For example, PCB exhibits a pronounced phasing-out period from 1997 to 2003. This sharp phasing-out course does not reflect reality, as it is assumed that double-glazed windows and sealants containing PCB are re-placed in an elongated way in relation to current maintenance and renovation of the actual buildings.

However, based on the assumptions and the results of the model, it isanticipated that in these years (year 2002 and a several years on) we will experince a "PCB-peak" in construction waste. Furthermore, it is expected that PCB will be non-existent in waste from the construction industry by the year 2025 and that in years to come it will most likely only be found in relation to double glazed windows and sealants.

Based on the model calculations the following amounts of PCB are predicted to be found:

Amount in year 2001: Approximately 58 tonnes
Amount in year 2010: Below 10 tonnes
Amount in year 2025: Around 0 tonnes

4.3 Briefing about identification and handling of PCB in building waste

Capacitors and electrical products that contain PCB are in general easy to identify, collect and handle. In Denmark there are some general rules and regulations for the collection and handling of waste containing PCB. This also means that capacitors and other electrical products within buildings are delivered to certified waste contractor, who handles the waste products accordingly.

Double glazed windows produced in 1976 or earlier can theoretically contain PCB. In general it is easy to identify windows containing PCB (in the glue in the frame) as they are most often marked with manufacture identification (short name, brand name, abbreviation etc.) and production year.

PCB in sealant is difficult to identify, collect and handle. It is impossible to identify whether a sealant contains PCB or not just by looking at it. Samples of the "suspected" sealant must be taken and sent to a laboratory for chemical analysis.

Sealants that cannot be ascertained to have no PCB content will most often be incinerated or send to a landfill, depending on the kind of building component or material the sealant is attached to.

Similar model calculations, graphs (as Figure 1 above) and discussions have been made for the other eleven substances listed above.

5. CONCLUSIONS AND RECOMMENDATIONS

The general conclusions of the project are that:

- The quantities of harmful substances in building waste will be a problem in the years to come.

- A special effort in relation to the identification, collection and disposal of PCB has to be formulated.

A summary of the main recommendations from the project is given in the following.

- Prioritisation and detailed assessment of the identified harmful substances.
  It is recommended that effort is put into the procurement of detailed information about the streams of the twelve substances in building waste in order to prioritise and plan future initiatives.

- Technical investigations.
  It is recommended that technical investigations are performed to reveal the possibilities for (clean) removal and handling methods of building materials containing harmful substances to reduce the amounts that are incinerated.

- Information and future initiatives.
  It is recommended that efforts are made within the construction sector to provide information and education in relation to the handling of harmful substances in building waste.
  For Denmark, which is the geographical area that is covered in the project, it is particularly recommended that the Danish Demolition Association ("Nedbrydningsbranchen") is prescribed to implement effective methods for the identification, removal and handling of harmful substances. This can be done by following the addendum to "Nedbrydningsbranchens Miljøkontrolordning 1996" (NMK 96).

Finally, when the technical foundation for a more comprehensive handling of building waste is established in Denmark, it is recommended that guidelines and rules are formulated as an addendum to local waste regulations, thereby ensuring the effective implementation of new or improved methods of waste handling.

An actor-oriented approach to environmental indicators for buildings and groups of buildings

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1. INTRODUCTION

A key objective of the development of Environmental Indicators for Buildings **(EIFOB)** is to facilitate the communication of environmental information between the different decision-makers involved in the course of a building's life cycle and to foster the consideration of environmental aspects. Powerful indicators therefore may not be based on environmental scientific knowledge alone. They also have to consider the explicit and implicit demands of the different relevant actors. This paper takes its point of departure in the social embedding of the EIFOB. It describes and analyses different views of EIFOB revealed by different actors in interviews, indicates lines of conflict and discusses possible conclusions for the designing of indicators. The paper displays preliminary findings of an ongoing Ph.D.-project aimed at developing a set of EIFOB that pays equal attention to environmental scientific and to social scientific demands. It focuses on municipalities, clients, consultants, users and administrators as core actors and the development of the district plan, the project design and the operation and administration of the building as the corresponding decision-making situations.

2 METHOD AND THEORETICAL BACKGROUND

In our study we have entered into two domains: In the environmental scientific domain we refer to an LCA approach (Wenzel 1997) and have carried out a comparative analysis of current indicator approaches and assessment methodologies in the construction sector (Dammann & Hansen, 2002). We analysed the Danish and a number of foreign and international indicators systems for among others environmental aspects considered, modes of quantification and decision-making situations and user groups addressed. In the social scientific domain, which is central to this paper, we perform an analysis according to the theory of the social construction of technology:

2.1 THE SOCIAL CONSTRUCTION OF TECHNOLOGY (SCOT)

SCOT (Bijker 1995) is one of the theories most often employed in studies that deal with the relation between technology and society. Its basic tenet is that society determines wether a technological artifact is 'working' or not ('artifact' including both 'hardware' like e.g. bicycles and other machines and 'software' like e.g. production methods or environmental indicators). With other words: the 'working' of a technology is not an inherent characteristic of the artifact but socially constructed in the negotiations between the relevant social groups.

One of the core tasks in a SCOT analysis is to describe how the different relevant social groups interpret the artifact. In the development of the modern bicycle for instance, the group of well-to-do young sportsmen saw the rather expensive high-wheeled bike as a well functioning technology, as it perfectly met their needs of displaying their wealth and their athletic skills and impressing the girls. Those, on the other hand, who were looking for a cheap and safe means of transport, saw the high-wheeled bike as a non-functioning technology (Bijker 1995). From the scientist SCOT demands to treat these different and conflicting views according to the principles of 'impartiality' and 'symmetry': Regardless of whether the scientist evaluates a belief as true or false, as rational or irrational, s/he must search for the causes of its credibility in a symmetrical way: both types of belief are explained in the same way, i.e. in reference to social factors.

Unlike previous, exclusively historical studies (e.g. Haugbølle-Hansen 1997), this study applies SCOT in a prospective way. It investigates the different actors' views on current indicator approaches and related subjects and draws conclusions for the designing of an artifact not yet existing: the 'environmental indicators for buildings' (EIFOB) that are to be a step closer to being commonly accepted.

2.2 QUALITIATIVE INTERVIEWS AND WORKSHOPS

In a first series of qualitative interviews with representatives of the actor groups municipalities, clients, consultants, administrators of buildings their interpretation of environmental problems, the value of indicators in decision-making processes and the role of the other actors in the building process were studied. First findings and hypotheses were presented to the interviewed in a workshop for feedback. After an analysis of the interview transcriptions, the workshop-feedback and additional literature provided by the actors, the results of which are presented in this paper, another series of interviews with deepening questions will be carried out. In subsequent workshops representatives of the relevant social groups are then invited to discuss different proposed sets of indicators – a test implementation of the indicators in a 'social laboratory' providing us with hints for the final development of a set of useful indicators.

3. THE ACTORS' VIEWS

3.1 Introductory remark

Considering the limited space of this paper we decided not to display primary results in the form of citations from the interviews but to start at the level of general patterns and attitudes indicated in the interviews. It lies in the nature of this qualitative study at this early stage that the results sketched here cannot be read as sharply defined axioms. They shall serve as points of departure for a discussion and a closer inspection in the next series of interviews.

3.2 On relevant environmental problems

The interviews revealed two main attitudes with regard to the question, which environmental aspects are to be considered important. They can be described as 'the global' and the 'local' attitude. Actors with **the global attitude** are mainly concerned about environmental aspects with a global dimension like global warming, consumption of scarce resources and stratospheric ozone depletion. The environment is mainly perceived as the very basis of our life, which is profoundly threatened by our present consumption patterns. Local measures are important as contributions to global improvement. Since global environmental problems are usually not directly perceivable by sensing but only via the detour of measurement, data interpretation and the distribution of the results in the media the global attitude has a

rationalistic element. Representatives of this attitude are people who in their professional positions are dealing with environmental improvement in the building sector on a superior level and with a relative financial freedom, freeing them from very clientele-biased viewpoints: indicator developers, municipality officials and NGO activists. Motives were scientific interest, a general feeling of responsibility, the wish to follow up national policy targets (e.g. with regard to reduction of greenhouse gases) as part of their work. Actors with the global attitude saw actors with a more narrow scope in a negative way: as less environmentally conscious, hypocritical and environmentally illiterate. To make them understand the global aspects is a communicative challenge. Because EIFOB are seen as a help to raise awareness of the building's contribution to global environmental problems they shall focus on these problems.

Actors with **the local attitude** are mainly concerned about their own immediate life world and with environmental aspects only in so far as they affect themselves directly. They are typically concerned about the indoor climate (including e.g. temperature, moisture, smell, touch e.g. of material surfaces), noise and the quality of the immediate outdoor environment. The sensual perceivability of the environmental aspects of the building is crucial. Representatives are e.g. parents of children in day-care institutions, officials dealing with day-care institutions and self-builders who want to realise their vision of ecological housing. Their motives are the wish to feel comfortable, concern for their children's health, pedagogical ambitions, the wish to improve something here and now and be able to perceive the improvement.

From EIFOB these actors demand that they focus on the local environment. If the indicators also consider the global environment they shall preferably confirm, that what is good locally is also good globally. As LCA-based indicators can happen to spoil the picture of the 'environmentally correct' local solution, they are met with mistrust.

3.3 On EIFOB

Several of the interviewees were not familiar with the idea of 'environmental indicators' at all but had been using 'anonymous' indicators[1] instead to characterize the environmental friendliness of a building. Among those, who had an explicit opinion about EIFOB, we observed two competing indicator concepts: the LCA-based concept and the concrete-means-based concept. One interviewee voiced concern that any kind of indicator could lead to buildings optimised according to the indicators and not according to the objectives behind the indicators like rules for the construction of sailboats for races lead to ill proportioned but nevertheless winning boat designs.

The LCA-based concept is a result of the observation that a focus merely on concrete means can lead to hypocritical results due to a lack of knowledge of where the crucial environmental pressures really occur. In one case (Foldager, 2002) the client put his emphasis on the wall construction of local unburned clay. At the same time he provided only insufficient insulation in the roof. As a consequence the energy consumption for heating by far surpasses the energy savings from the clay wall in the building phase. Another problem is that the environmental performance of a concrete means or principle depends on the concrete context: high insulation may be the key to energy savings in a rural context. But in an urban context the reduction of

[1] Bell and Morse call these 'qualitative implicit indicators' (Bell & Morse, 2001). What we mean are the characteristic of buildings that people think of when they say 'This is an environmentally sound building' without referring to a certain evaluation system. 'Anonymous indicators' may for example be a grass roof, a wooden construction, use of solar energy, … .

electricity consumption may be the crucial point, because buildings are heated with waste heat from electric power plants. LCAs allow us to identify the environmentally favourable solutions despite these difficulties, because they systematically quantify the numerous environmental pressures that occur in the entire lifecycle of the building or building material, thus making alternative solutions precisely comparable (Wentzel et al., 1997). It is a characteristic of LCA-based indicators that they refer to some kind of IT-calculation tool. Though the author of the Danish tool, an engineer at the Danish Building and Urban Research Institute, stated to have made an effort to make it user friendly, architects consider it an 'expert tool' and are reluctant to use it themselves. The actors in favour of the LCA-based concept, who usually have an engineering background, want to have scientific proof of the environmental correctness of the indicator-based decisions. They want to be able to detect and avoid the pitfalls of environmental pressures hidden in the lifecycles of seemingly good solutions. In general the actors favouring an LCA approach expressed an inclination to concepts such as analysis, proof, measurement, quantification, control – concepts that we summed up with the term **'rationalist paradigm'**.

The concrete-means-based concept on the other hand originates in the practical necessity to choose between different solutions when building a house. The available alternatives are evaluated on the basis of common sense judgement (e.g. 'Wood grows naturally, steal needs to be produced – so a wooden construction must be the environmentally friendly solution.') or general tenets which may often be part of an unexpressed 'tacit codex'. 'Low consumptions are good.', 'Natural and local materials are good.', 'Renewable energy is good.', 'Natural ventilation is good.', 'High insulation is good.', 'Chemicals are bad.' are examples of such tenets. Some actors expressed a strong affection for certain concrete means, which for them constituted a substantial element of their concept of an ecological house. The principle '*natural* ventilation' e.g. had a strong appeal to architects when it was presented in a course for environmental management in project design, even though an LCA indicates that it can perform worse than mechanical ventilation, depending on the context. The actors in favour of this concept expressed a need for simplicity and clarity in the guidance to environmentally sound solutions. They want a system close to the decisions they have to make, preferably even a gross list of 'good' materials, constructions and design principles. To describe this inclination to simplicity, visibility and the concrete we use the term **'sensualist paradigm'**.

3.4 On the roles of the different actors

Municipalities see themselves as pacemakers. Especially in their role as clients, their environmental demands and use of indicators can force contractors to use these indicators if they want to compete for the lucrative public building tasks. With regard to EIFOB this dependency implies a differentiation between what we call 'first- and second-degree indicator users': **'First-degree users'** (typically municipalities, other administrative bodies and indicator developers) are interested in the EIFOB debate because they are concerned about the environmental performance of buildings. They see EIFOB as a means to make precise and controllable demands to contractors. **'Second-degree users'** are those, who see EIFOB mainly as a currency or a product brand. They are in the first place interested in being competitive in the emerging market of environmentally sound building. Another example of this group are enterprises that see their buildings as a vital part of their green image. They have a tendency to consider visibility of their environmental efforts to be more important than an LCA.

Concerning **the client-consultant-relation** a professional client expressed the wish to be able to make environmental demands to contractors in a very simple way. He considered it the

consultant's responsibility to evaluate the alternative concrete means in detail and to propose solutions that can meet the overall environmental demands. In a private ecological housing project the exact opposite occurred: Here the clients rejected the environmental mean suggested by the consultant on the basis of an LCA (higher insulation in the roof) in favour of the measure they had chosen themselves (walls of unburned local clay) (Foldager, 2002).

Another significant feature of the inter-actor relations is **the architect-engineer-conflict** about the **power to define** the 'environmentally correct building'. Here architects expressed the feeling that the concept of LCA-based EIFOB moves the definition power from their mainly concrete means oriented field of competence into the domain of the engineers. Also the request of an architect in our workshop to integrate esthetical aspects into the indicator set revealed the wish for indicators that are close to one's own field of competence. Engineers found it difficult to communicate the advantages of LCA-based EIFOB to architects.

3.5. Lines of conflict

The analysis of the actor groups revealed two major lines of conflict: - the dichotomy between LCA-based indicators and indicators based on concrete means and the dichotomy between the 'global and the local attitude'. Brought together as the axes of a Cartesian system these two lines of conflict unfold the territory in which the indicators have to find their 'social habitat':

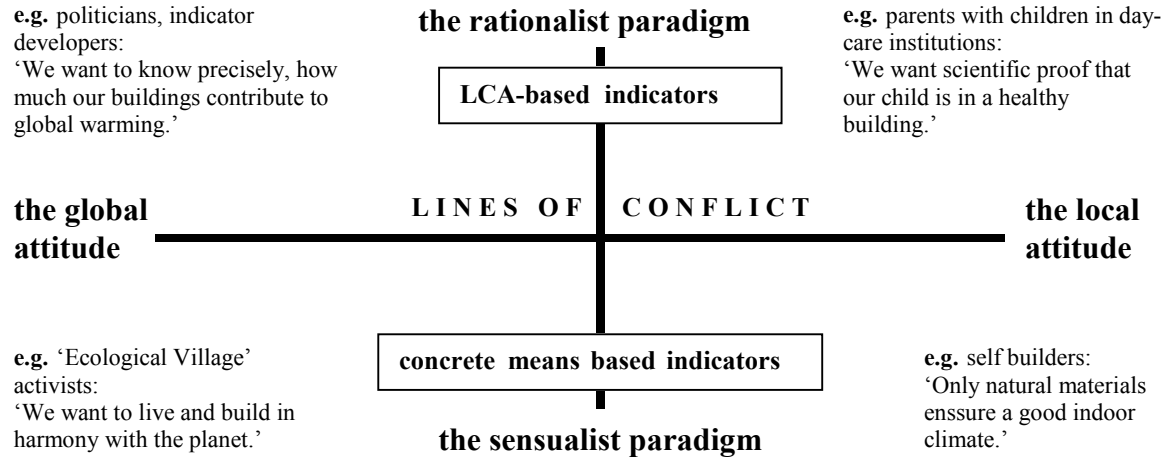

Figure 1 Lines of conflict between actors' attitudes towards EIFOB, exemplified by (idealized) typical statements

4. DISCUSSION AND PERSPECTIVES

The preliminary study of the future users of EIFOB illustrates how difficult it is to provide a set of indicators that satisfies everyone. The conflict line between the local and the global attitude could be overcome by indicators, that simply cover *all* the environmental aspects considered relevant. The dichotomy between the LCA-based and the concrete means-based approach is more difficult to overcome as it is embedded in two genuinely different mindsets, which in the very end refer to different epistemologies and different emotional needs. It is hard to love CO2 savings but you can have an affectionate relationship to your solar collector.

Table: The two paradigms and associated dichotomies

the rationalist paradigm	the sensualist paradigm
LCA-based indicators (quantitative)	concrete-measures-based indicators (qualitative)
engineers	architects

measurement	faith
atomistic	holistic
each case needs to be checked individually	ideas and universal principles
Aristotle	Plato

Indicators cannot build houses. Therefore the actors always have to decide upon concrete means. From an environmental-scientific point of view these means need to be evaluated with LCA-based indicators. These indicators however have to be 'interpreted' to the level of concrete means[2]. In order to avoid the problems of merely qualitative checklist indicators this interpretation has to be a continuous process that in its recommendation of concrete means also pays respect to the different kinds of local contexts and the development of innovative solutions. A bilateral learning process is necessary: those in the rationalist paradigm have to learn to translate LCA-based EIFOB into concrete means, and those in the sensualist paradigm have to learn to check concrete means in an LCA approach. This process may have increased chances to be appreciated across the actor groups if all actors are represented in an interdisciplinary 'interpretation panel'. The outcome could either be a set of EIFOB comprising of both LCA-based and concrete-means-based indicators or a catalogue with good and bad examples of concrete means and their performance in relation to the chosen LCA-based indicators. Such a twofold concept would also meet the different needs for abstraction and concretization expressed at the different levels of decision-making.

However, the future work will show, how far a consensus on EIFOB can be reached. As the indicators also touch the very sensitive questions of professional competence, definition power and of market shares in the emerging market of ecological building power structures are likely to also play an important role in the final coining of EIFOB.

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[2]The book by Marsh et al. (2000) is a good example for such a process: It contains the evaluation of a row of buildings types and constructions with the LCA-based IT tool 'BEAT2000' and formulates general design recommendations for architects.

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Delivering sustainable construction

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1. INTRODUCTION

At present the situation regarding sustainable building in Britain is, briefly, as follows.

- Increasing numbers of engineers and architects are able and willing to incorporate 'sustainable technologies' in their buildings. They are assisted by a growing number of guides to sustainable building.
- The numbers of buildings claimed to be 'sustainable' are growing – from small houses in the countryside to large office blocks occupied by large corporations or government departments.
- BREEAM-for-offices is becoming more widely known and the government, as a major construction client, is committed to relying on BREEAM to help meet bold targets – by the end of 2003 all new Government office buildings will need to attain the Excellent rating using BREEAM. Other types of client are becoming aware of BREEAM and are sometimes incorporating the need to achieve a certain BREEAM rating in building briefs.

However, the situation is not all rosy.

- The numbers of 'sustainable technologies' in many building schemes diminish steadily from those featured in a competition entry, to outline design, scheme design, detail design and in the completed building.
- While many buildings are claimed to be 'sustainable', there is often little reliable evidence to justify such claims. Most commonly, the overall degree of sustainability is ignored in favour of focusing on one or two items such as the use of timber in the building or a few photovoltaics providing a small amount of energy.
- The vast majority of buildings assessed using BREEAM are assessed at the scheme design stage when many of the credits are awarded on the strength of an intention to do something. Many are the credits that are lost later on as contractors challenge the inclusion of various features in the name of 'value engineering'.

Most importantly, perhaps, there is a growing divergence of uses of the word 'sustainable', which inevitably can lead to misunderstandings:

- for many architects sustainable means the same as 'green' or 'environmental'. It often results only in the use of certain visible features, such as photovoltaics or wind turbines, and 'sustainable' timber in the structure and façade.
- For many engineers and some architects it means achieving a low-energy building and the use of natural ventilation.

- For many members of the project team it means little more than achieving BREEAM Very Good or Excellent at scheme design stage.
- In the corporate world, many use 'sustainable' to mean maintaining a viable business, and, perhaps, to ensure a company is included in the Dow Jones Sustainability Group Index (in the USA) or the FTSE-4-Good Index (in London).
- In local authorities, which are responsible for setting local development strategies and giving planning permission for new building projects, the emphasis tends to be on the social aspects of sustainable development – employment, social inclusion, amenities, public transport, and so on.

It was in the context of this scenario, that the UK-based Construction Industry Research and Information Association (CIRIA) undertook, during 2000-2001, the production and publication of a guide that would help all those engaged in construction projects to understand their role in the wider context and, hence, to become more effective in achieving projects which are 'more sustainable'. The contract for researching and writing this guide was awarded to Buro Happold Consulting Engineers, under the direction of Bill Addis, the author of this paper, working in collaboration with Roger Talbot of Thirdwave Scotland. The result was the publication by CIRIA in December 2001 of ***Sustainable Construction Procurement: a guide to delivering environmentally-responsible projects***.

2. A PROCESS APPROACH TO SUSTAINABLE CONSTRUCTION

The approach advocated in the guidance is based on well-established principles that are used to manage processes in order to ensure results are delivered:

MANAGEMENT ACTION	TYPICAL IMPLICATION FOR SUSTAINABLE CONSTRUCTION
Articulate why a certain outcome is desired	Identify and understand the drivers for sustainable construction
Establish the desired outcome	Devise a specification of sustainable / environmental performance (e.g. a target rating using BREEAM or similar)
Agree the means for assessing the outcome	BREEAM or similar, energy consumption, local authority Sustainability checklists,
Devise and implement a suitable management procedure or system	Establish appropriate persons with responsibility for ensuring delivery of desired outcome
Assess or measure the outcome to ensure it has been delivered	Undertake BREEAM assessment at completion, measure actual energy consumption in use,

3. DRIVERS FOR SUSTAINABLE CONSTRUCTION

The research identified the client as single most important driver needed to ensure that a building will be more sustainable or environmentally-responsible. However, the client in turn is responding to stimuli from its many stakeholders, both inside and outside the organisation:

- Employees and their families
- Immediate neighbours, local community
- Pressure groups
- Government, regulators
- Customers or clients, end users
- Partner organisations, service contractors
- Investors, shareholders, trustees
- Pension providers

Responsible clients express their sustainability aims in a policy statement which can then act as a stimulus for a cascade of sustainability action plans for social, economic and environmental issues – equal opportunities, health and safety, community relations, green purchasing, green travel plan, stakeholder pensions, training, energy and water use, biodiversity, air and water quality, waste, etc. One action plan will relate to the procurement of buildings and this, in turn, will enable sustainability aims to flow downwards through the briefing process, a Sustainability Management System for a project, the design and construction phases and, finally, into the operational phase of the building. This whole-project approach helps ensure that sustainability pervades an entire project and ensure the greatest likelihood that sustainable technologies are actually incorporated into buildings. Being a client-focused approach it helps the client to articulate its sustainability goals and set up the project in the best way to achieve them.

4. SPECIFYING SUSTAINABLE AND ENVIRONMENTAL PERFORMANCE

Specifying environmental and sustainability performance can vary from rather imprecise ideas of 'green building' to very precise definitions of the internal climate of buildings and the emissions of a whole variety of noxious or polluting gases and liquids, not only when a building is being used, but also during construction and the manufacture of all the components which are used in its construction.

Construction clients and their project teams need to choose and set their own performance targets, for without these it will not be possible to guide or to brief the designers as to what they must achieve, nor to assess whether they have achieved it. Many means are now available including benchmarking, Key Performance Indicators (KPIs), life cycle assessment (LCA), environmental impact, Ecolabelling, etc. Most importantly, the performance needs to be defined in ways that can be assessed, for instance:

- Depletion of natural resources (materials, energy, water, land), especially if scarce
- Generation of polluting by-products ('greenhouse' and ozone-depleting gases, toxic materials, waste).
- Amount of landfill generated
- Change to the local or global ecology and microclimate
- Issues related to impact after a project's useful life (demolition, residual materials)

For more sustainable development, economic and social issues need to be included, such as:

- Impact on the community surrounding the development including mobility and access issues, transport and local amenities
- Impact on employment, education and training of local residents
- Consequences for the local economy

However, the large number of possible parameters makes the description of sustainability and environmental performance extremely complex, especially since:

- there is no agreed set of parameters that must be included, nor their relative weighting;
- the goal posts are moving – what was considered excellent environmental performance in 1990, is now only average;
- best practice is usually ahead of statutory requirements and benchmarking data;

In practice this means that the method of assessing sustainability or environmental performance must be devised and agreed ("bought into") by as many as possible of the relevant stakeholders.

In selecting a type and level of performance to specify to a design and construction team, it is vital that the precise reason for attaining the performance is well understood and articulated. One client might want to be 'best in the field' while another might want to be merely 'above average' and a third, 'the minimum possible'. Specialist environmental advice is essential to setting appropriate levels of environmental performance. There is little point in voluntarily setting a level that is difficult or costly to meet! Sometimes the specification might be very short, but have far-reaching implications.

4.1 Construction phase

Many potential environmental impacts are covered by environmental legislation and most good constructors now implement effective Environmental Management Systems. In addition, however, a client may want to specify additional sustainable performance goals such as:

- upper limits to energy and water used in construction
- limits on the volumes and types of waste that are removed from site, and upper limits to the proportion sent to landfill
- employment and training of local people on the project.

In Britain the performance on site is addressed by the Considerate Constructors Scheme which requires contractors to demonstrate they are implementing good, i.e. socially- and environmentally-responsible practices on site.

4.2 Operational phase

Target environmental performance data for many buildings is now easy to come by, and much can be specified in quantitative terms, making it relatively straightforward to monitor in service. For example:

- Energy – kWHr/m^2/year
- Water – litres per person per year, or per square metre, depending on building function
- Waste – skips of different types of waste per year; degrees of waste segregation; proportion of waste recycled
- Air quality – temperature, humidity etc. as specified in CIBSE design guides; the inclusion of an air leakage rate within the specification should also be considered
- Noise – as specified in health and safety legislation and design guides; maximum levels of ambient noise are also included in BREEAM
- durability – linked to the building life, levels of maintenance and refurbishment, etc.

4.3 Specification linked to assessment

An alternative method of specifying environmental performance can be to require that a building achieve a certain score or rating using an established environmental impact assessment method, for instance a BREEAM Rating of Very Good or Excellent. This has the enormous advantage that it is clear, succinct and widely understood. However, the disadvantage is that BREEAM and similar schemes are not, at present, applicable to all

building types so it is difficult to compare the performances of different types of buildings. BREEAM-for-offices now includes the option of using the ENVEST, the BRE's software which estimates, in Ecopoints, the environmental impact of the materials employed.

5. MEASURING SUSTAINABLE AND ENVIRONMENTAL PERFORMANCE

As mentioned above, the method used to measure the environmental or sustainability performance is likely to be linked to the method by which the performance is specified. It is important to consider how detailed or precise an assessment should be. A more precise assessment will take more time and be more costly. It may also be a spurious precision – assessing the impact of some activities to three decimal places is futile if others can be estimated to only +/- 50%.

Finally, there is the uncertainty attached to predicting impact at the design stage. No building is built precisely as designed. Specifications change, and the exact sources or constituency of materials and components can vary between one batch and another. For example, the embodied energy of concrete varies enormously according to the sources of the aggregate, the energy used to manufacture the cement and the distances involved in delivery to site.

An assessment method such as BREEAM is a compromise – it is quite quick to undertake and costs only a few thousand pounds per building. It is not a very precise assessment compared, for example, with those undertaken on consumer products such as cars and electronic goods, but it is precise enough for its main purposes, i.e. to help the client and design team to reduce environmental impact and to compare this impact with similar buildings.

6. SUSTAINABILITY AND ENVIRONMENTAL MANAGEMENT SYSTEMS

In order for a client's sustainability goals to have an influence on a finished building, it is vital that they are introduced as early as possible and incorporated alongside other aspects of the project management. Failure to achieve good sustainability or environmental performance usually occurs for three reasons:

- The client's sustainability or environmental aims have been inadequately formulated or not incorporated into the project brief.
- The project team and management structure are set up in ways that make it difficult to achieve the client's sustainability aims.
- Sustainable technologies and features are removed from a scheme when it proceeds into the construction phase because of the considerable influence of contractors, project managers and others who are keen to reduce costs.

7. STRUCTURED GUIDANCE

A structured approach is used to present the guidance on sustainable construction procurement under the overall headings *Why?*, *What?*, *How?* and *When?*. The guide begins with an overview of the ideas of sustainable development, sustainability and environmental responsibility and why they need to be addressed in construction projects, both by clients and the construction team. The business drivers which can encourage client organisations, developers and construction companies to address sustainability are also reviewed.

The following section (*What?*) describes how many exemplary organisations address environmental responsibility and sustainability issues in their business by means of policies, plans and environmental management systems. This addresses the need for an environmental

or sustainability policy about the buildings they occupy, maintain and adapt and the new buildings they commission as well as the opportunities for publicising achievements in sustainable and environmental construction by means of annual reports for shareholders and other stakeholders.

The remainder of the guide (*How?* and *When?*) first explores, at a strategic level, how the construction client can identify the sustainability and environmental issues in a project and devise means of controlling them at the pre-design stage, through the adoption of appropriate plans and systems of environmental and sustainability management and through the selection and management of the procurement process. Finally specific guidance is given about how sustainability and environmental issues can be dealt with during the four key phases of construction projects – feasibility and briefing, design, construction and operation. The reader is also pointed towards a wealth of further guidance and information in several appendices, books, articles and websites.

8. CONCLUSIONS

The research undertaken and experience gained on recent building projects has led to the following conclusions about using the whole-project approach to enable project teams to meet client aspirations and deliver sustainability more effectively:

i. Ensure the client's environmental or sustainable aspirations and policies are covered in the project and design briefs to provide the project team with the appropriate direction.
ii. Ensure the project team has the skills appropriate to undertaking the environmental and sustainability aspects of the design and seeing them through to project completion.
iii. Define appropriate sustainability and environmental performance criteria and targets.
iv. Ensure environmental performance and sustainability issues are on the agenda of appropriate project and design team meetings.
v. Arrange regular assessments of the project's predicted environmental / sustainability performance in order to monitor progress towards the targets stated in the brief, e.g. environmental impact, energy consumption, BREEAM rating
vi. Provide reports on progress to the client and full project team. These should include reports for the client on how the project performs against the organisation's general sustainability or environmental policy. This will provide the client organisation with data it can use in its environmental management system as well as any annual public reporting of environmental or sustainability performance.

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Evaluating the environmental benefits of using structural timber in buildings

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1. INTRODUCTION

It is widely known that the environmental impact of a building can be reduced if timber from sustainable sources is used in preference to alternative materials. Indeed, for some architects it seems almost to be sufficient to use some timber in the roof structure and external façade for them to claim they have designed a sustainable building. Structural engineers involved in a wide range of building projects, in various countries, such as those working in the author's firm, usually want to have more precise information than this, for several reasons:

- to demonstrate how much less the impact of a timber design would be, compared to other materials such as steel, concrete and aluminium;
- to assess the relative embodied energy impact of the timber elements compared to the rest of the building,
- to assess the embodied energy impact compared to the whole life impact including energy in use.

Only if this analysis can be done will it be possible for the engineer or the sustainability adviser to undertake an important part of their professional duties, to inform the client, architect and other members of the project team as to the relative environmental merits of different schemes. Such environmental merits can then be assessed alongside other criteria such as appearance, cost, ease or speed of construction, life cycle costs, and so on.

Unfortunately, the environmental impact of construction materials is a thorny issue. Any assessment must be based on many sweeping assumptions and approximations that underlie all life cycle analyses underlying data such as the Environmental Profiles collated by the BRE in Britain. For instance:

- source of materials and transport distances
- type and source of primary energy used for materials transportation, construction processes and building-in-use
- length of life assumed
- variations between materials specified and those actually used.

Notwithstanding these difficulties, several software tools have been developed to help engineers with such calculations and comparisons, and one of these, ENVEST, has been used to investigate the relative environmental performance of timber and some alternatives for two recent projects undertaken by the author's employer, Buro Happold. The purpose of the investigations were twofold:

- to obtain some numerical data to compare timber with alternative materials

- to evaluate the potential for using a tool such as ENVEST *as a matter of course*, in the design stages of building projects.

2. ENVEST AND UK ECOPOINTS

ENVEST is a software package for estimating the lifecycle environmental impacts of a building. It has been developed by the BRE, principally for use on office buildings, and considers the environmental impacts of:

- Materials used in construction.
- Resources consumed over the building's life.

All environmental impacts are measured on a single scale in UK ***Ecopoints*** allowing the user to compare different designs and specifications directly.

A UK Ecopoint is a measure of the overall environmental impact of a particular product or process covering the following environmental impacts, weighted according to the significance of the impact:

- Climate change
- Fossil fuel depletion
- Ozone depletion
- Water extraction
- Minerals Extraction
- Waste disposal
- Acid deposition
- Human toxic air pollution
- Eutrophication
- Pollution resulting from transport
- Human toxic water pollution
- Ecotoxic water pollution
- Ground level ozone creation (summer smog)

100 UK ecopoints are equivalent to the environmental impact caused by one UK citizen in one year. One ecopoint is approximately equivalent to the environmental impact due to any of the following:

- Travelling 65 miles by articulated truck
- Manufacturing ¾ tonne of brick (250 bricks)
- Consigning 1.3 tonnes of waste to landfill
- Using 320 kWh electricity
- Using 83 m3 of water

To use ENVEST, the overall form of the building is defined and its dimensions fed in. The various construction details are specified by choosing from a number of drop-down menus, for instance whether a steel or concrete frame is used, the column spacing, what type of façade or windows, the roof construction, and so on. From basic data such as this, the programme makes assumptions about further data – for instance the weights of steel and concrete in a roof or floor structure are calculated assuming certain typical arrangements, span-to-depth ratios, percentage reinforcement, and so on.

At every stage the user can see the total number of Ecopoints that have been accumulated and, by ‘trial and error’, investigate the effect of making different choices. The output is available in numerical form and as a series of bar charts, etc. that show the elemental breakdown of total figures.

3. THE BUILDINGS STUDIED

Weald & Downland museum

The new Conservation Centre and Store at the Weald and Downland Open Air Museum is using an innovative timber gridshell design in the first such building in the UK. The basement consists of a sunken archive space of earth-protected masonry. The main workshop area above the basement is constructed of a timber gridshell clad with a loose system of hanging plates of hardwood and glazing, and the top of the structure will consist of a curving ribbon of watertight monolithic roof.

The timber gridshell alternative was, in fact, compared to both steel and concrete. However, the latter two were found to so similar in their ecopoint rating (especially in the light of other approximations) they are presented as a single result.



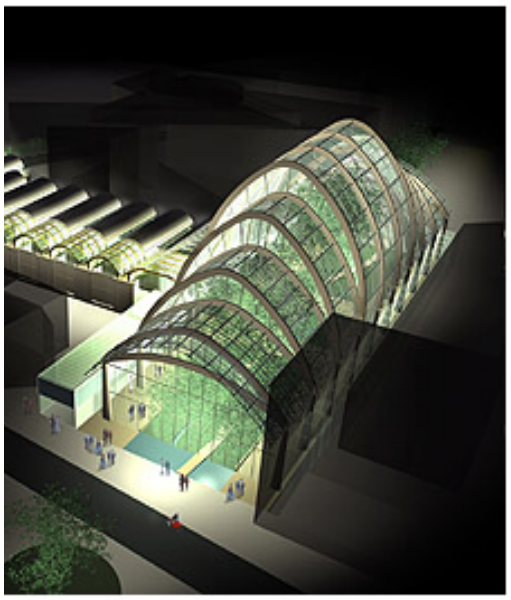

Fig. 1 (above) Weald & Downland Museum

Fig. 2 (right) Sheffield Winter Gardens (architect's impression: Pringle Richards Sharrat Architects)

Winter Gardens Sheffield

The Sheffield Winter Gardens (still under construction) will be an enclosed glazed public space containing a wide variety of tropical plants and trees from around the world, including eucalyptus, palms and bamboos. Entrance to the gardens will be free and all year round from 6am to midnight.

The superstructure of the Winter Gardens will be constructed of a series of Glulam arches ranging in height from around 14m to over 20 metres in the centre of the building (see Plate 1). The relative rarity of the use of Glulam for large buildings in the UK presented the opportunity for Buro Happold to undertake an assessment of its 'sustainability' in comparison with materials.

4. METHODOLOGY

ENVEST was developed for use on office buildings built using relatively standard construction methods and materials. Neither of the two buildings analysed is an office building. Both have roof structures with unusual geometries (outside the vocabulary of ENVEST) and are made with materials – green timber and Glulam – which are not included in ENVEST's range of choices.

Nevertheless, ENVEST was used. By making a number of suitable approximations, in collaboration with the developers of ENVEST at BRE, the programme could be 'fooled' into providing results which have enabled a number of conclusions to be drawn..

For the green oak timber gridshell at Weald & Downland Museum the main adjustments were as follows:

- the building was represented as a rectangular, single-storey concrete frame building with an oversized pitched roof to enable ENVEST to calculate the impact of the timber frame structure. To this total an additional impact (in ecopoints) was added to account for the first floor structure that ENVEST would not include in its pitched roof calculations. The area of the lower storey was taken as 750 m^2, and of the upper storey, 1050 m^2.
- Both Glulam floor beams and the green oak gridshell roof were entered as standard timber products. The green oak would have a lower embodied eco-rating than used in ENVEST as it is not kiln-dried, and has probably been transported a shorter distance than an average timber consignment. From data available in the BRE's Environmental Profiles it is estimated that the green oak has an embodied energy of less than 50% of the 'normal' kiln-dried timber assumed in ENVEST.

At the Winter Gardens, Sheffield, the Glulam arches were compared with alternatives in steel, pre-cast concrete and aluminium. Among adjustments made were the following:

- the building was represented in ENVEST as a two-storey building with an average height of 5.7 metres. The roof was calculated from a point 6.3 metres above the floor of the upper storey.
- ENVEST does not include an Environmental Profile for Glulam and so this was calculated and approved by the BRE as in line with to their methodology.
- Plywood cladding on one third of the wall was not available as an option under cladding in the 'external walls' section, and was accounted for under the 'wall finishes' section. Two pieces of plywood of 24mm thickness are to be used in the development, and the only available option in ENVEST was 15mm thickness. To account for this, the area of wall that was covered by the plywood was shown to be larger than in reality. The same principle was applied to the York Stone paving where the option of 50mm York Stone was used within ENVEST while the actual thickness used in the Winter Gardens is 30mm. The area that it covered was reduced accordingly to give the required number of Ecopoints.
- The glazing used in the Winter Gardens was not an option available within the ENVEST programme. Bespoke calculations were obtained from the BRE for the frameless glazing used in the upper storey of the arboretum. The calculation of environmental impact was based on the weights of steel and Glulam used.

5. RESULTS OF ENVEST ANALYSES

Weald & Downland museum

The results of the analysis using ENVEST are presented in Table 1.

Before looking at the significance of the materials used in these alternative schemes, it should be noted that the energy used during the building's life dominates that associated with the materials used – 76% for the timber building, 60% for the conventional steel or concrete version.

Table 1 Comparison of impact of timber building option with alternative materials

	Steel / concrete	Proportion	Green timber	Proportion	Green / steel
Building element	Ecopoints	%	Ecopoints	%	%
Upper storey, incl. roof	8160	24	1100	4	13
Lower storey	5240	15	5010	19	95
Building services (embodied)	350	1	350	1	100
Total (materials only)	13,750		6460		47
Operational energy (30 years)	20,600	60	20,600	76	100
Total	34,350	100	27,060	100	78
Upper storey superstructure only	3000		100		3.5

The benefits of the timber clear – especially when only that part of the building (the upper storey superstructure) are looked at. The green oak roof has an ecopoint rating of less than 5% of the steel or concrete alternatives. When looked at in the context of all the other elements and materials in the upper storey, the gridshell solution is about 13% of the steel / concrete version. Looking at all the materials in the building this ratio rises to 47% and if the operational energy is included, the reduction achieved in the gridshell building is only 78%.

Winter Gardens Sheffield

The results of the analysis using ENVEST are presented in Table 2.

Table 2 Impacts of building elements in different materials

	Glulam	Steel	Concrete	Aluminium
Building element	Ecopoints	Ecopoints	Ecopoints	Ecopoints
Arches	70	2250	3260	4130
Remaining materials	18,610	18,400	18,060	18,390
Total (materials only)	18,680	20,650	21,320	22,520
Normalised impact	100	111	114	121

From the analysis of materials only, it is clear that the Glulam option offers an 11% saving in ecopoint rating compared to the nearest rival, steel. The arch structures themselves, however indicate a dramatic reduction achieved by using Glulam.

6. EVALUATION OF ENVEST AS A SUITABLE TOOL

Despite ENVEST being intended primarily for use on standard steel or concrete office buildings built using conventional construction methods, it is possible to stretch its use for to include other materials and non-conventional structural forms. In effect the ENVEST programme is being used as an Ecopoint calculator.

The standard output formats of ENVEST are not suitable for the analysis needed for this study and data had to be extracted and fed into a new spreadsheet for this purpose. The Ecopoint rating for some elements had to be added in manually (so to speak) after the ENVEST programme had produced its results.

Likewise, the heating and ventilation for the Winter Gardens building was not available within ENVEST and separate calculations will need to be made.

The following features would certainly be useful in future developments of ENVEST if it is to need the needs of basic analysis of the environmental impact of buildings:

- Ability to override automatic calculation of quantities and inputting of simple weights of materials to allow for options not included in ENVEST.
- Inclusion of more materials, especially those likely to be used by designers intending to reduce embodied energy impact.
- Ability to override automatic calculation of building energy calculations to allow for options not included in ENVEST.

7. CONCLUSIONS

This study has led to the following conclusions which are of significance to building designers:

i. Using timber can reduce significantly the embodied eco-rating (impact) of the building elements actually constructed of timber (by more than 95%).
ii. The use of green timber rather than kiln-dried timber can further reduce the embodied eco-rating of the timber elements by 50% or more. This points to clear benefits in using green timber.
iii. While using timber instead of steel or concrete can reduce the environmental impact significantly when that building element alone is considered, the reduction in the impact of the whole building is much less significant, especially when operational energy is included.
iv. To reduce the impact further, great attention should be given to avoiding, or at least reducing the use of concrete in buildings, mainly due to the large masses needed.
v. To design a building with a reduced environmental impact, consideration must be given to all elements of the building design, not just those made of timber.
vi. ENVEST is convenient to use to assess standard office buildings. For unconventional materials (including very low impact materials) and construction methods is lacks data and construction options which limits its use considerably.

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9. ACKNOWLEDGEMENTS

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Multi-actor and multicriteria methodological approach integrating sustainable development in the decision of a social building provider.

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1 CONTEXT

The social building provider is an essential actor of the regional planning network who must take care of the preservation and even improvement of the quality of live of local inhabitants. For these reasons, he must guarantee a response to the requirements of his customers (quality of the services offered, reduction of the harmful effects, …). He is also subjected to internal objectives which aim at the increasing of his profit (optimisation of the load factor of the residences). Besides, new legal constraints such as the Solidarity Urban Renewal law SRU (2000) in France, urges him it to ask questions and review his offer. Lastly, he tries to improve his image by working for the development of his heritage. He tries to integrate into his achievements the sustainable development criteria, as the French example shows with the development of High Environmental Quality constructions. HQE (1997).

The existing buildings will compose, for a large majority, his future heritage, which is why his actions mainly lead to operations of rehabilitation. Those buildings are not adapted to the present needs and it is then necessary to operate transformations which will increase the quality of life.
The phase of report/diagnosis and the feasibility study are specific to rehabilitation work. It takes place before the planning. The feasibility study makes it possible to make a strategic choice of the actions to be undertaken.
The feasibility study is based on the data concerning urban and commercial positioning and takes into consideration the competitivity characteristic of the settlement site. We also find the opinions of the tenants, the partners and the proximity staff (obtained thanks polls), the specification of the project, the heritage project and the financial and social impacts.

2 OBJECTIVES

The objective of our research work is to propose a methodological approach to help the social

building provider to take into account sustainable development criteria in the planning of his rehabilitation work and in the choice of innovating solutions proposed.
The approach facilitating the choice of the solution is based on two phases. In order to keep with the heritage scope, we offer a guideline to classify and structure his actions by evaluating heritage sites in comparison with sustainable development criteria. In a second phase, a technical and human diagnosis of the problem must be carried out by taking into account the importance of the phases before planning.

3 METHODOLOGICAL PROCEEDINGS

The proceedings, human based, help the building owner to define a strategy for the improvement of the quality of life of the tenants. They aim at guiding him in his choices of sites to be rehabilitated. They are intended to answer any type of problem facing the building owner and to be total and reproductible.

3.1 Principle

The methodology is based on the 7 following phases [figure 1]:

1. *Identification of the rehabilitation problem* and work estimation to be undertaken according to the expressed and implicit needs for the building owner and the tenants.
2. *Sustainable development evaluatio*n of the heritage sites where problems are posed thanks to the use of sustainable development criteria. The choice of useful criteria for the evaluation will be formalized by a multicriteria approach and the taking into account of the opinions of all actors of the construction life cycle.
3. *Choice and classification basis of the heritage sites* thanks to a comparative analysis of sustainable development values of the different sites studied.
4. *Identification of the technical solutions* and the existing behavioural practices.
5. *Behavioural and technical diagnosis* of the sites selected to define the behavioural and technical aspect of the problem posed.
6. *Experimental realization* on a test site based on one or more technical solutions and behavioural developments and the possibility of validating or improving them.
7. *Choice of the optimal solution*, made among the identified solutions thanks to the experimentation carried out on the site.

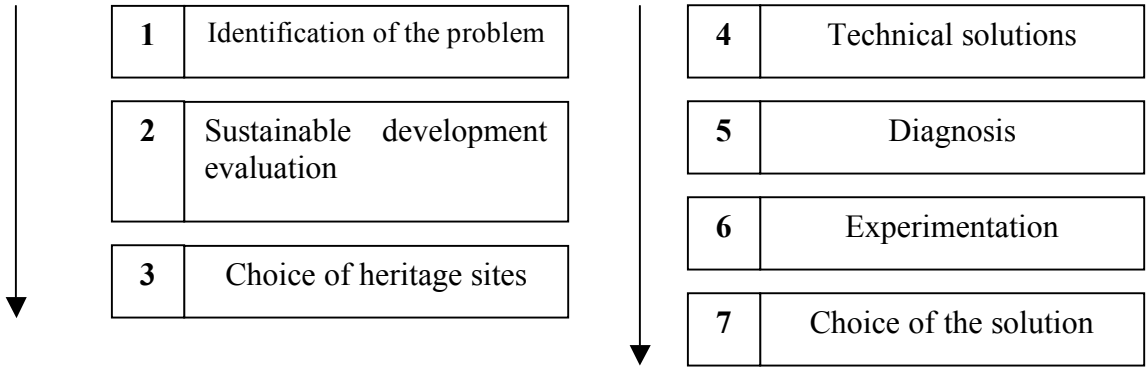

Figure 1 Different approach phases

This article presents in detail phases 2 and 5 which are the key points of the approach and which can contribute to the identification of innovating solutions.

3.2 Sustainable Development evaluation of the identified sites

The heritage of the building owner is composed of sites of different characteristics. Council flats are especially significant where the requirements in construction were crucial during the Sixties and Seventies (rebuilding after wars, demographic expansion).

These residences are primarily in big agglomerations, in towns centres, where they are integrated into other buildings with different objectives and in the suburban, where the density is more significant and the social mixity is weaker. We realise that in some rural zones, building are often marginalized compared to the existing framework.

Sustainable development evaluation of the sites consists in giving a value to the heritage site identified by the problems. This evaluation will be carried out according to the site characteristics, site neighbourhood characteristics and sustainable development criteria which must guarantee a choice respecting the needs for the current and future inhabitants.

Indeed, the actions on the site are not sufficient to meet to all the objectives of a sustainable development approach. The close neighbourhood, even the district, are also elements to be taken into account. Valdieu (2000). The environmental problems which are not considered within the site can find their solutions in the neighbourhood where the economic and social criteria are largely applicable.

3.2.1 Evaluation grid formulation. In order to carry out the evaluation, we have elaborated a criteria grid built in accordance with the "three E" of sustainable development (Environment, Economy, Equity). This grid integrates three corresponding columns which will have each the same weight during the evaluation and which will integrate their own criteria. GAY (2000). This criteria can be weighed up differently.

As an example, on the site studied [Table 1], an environmental criterion could be the energy performance, i.e. we will identify the type of heating which induces the weakest impact on the environment. On the neighbourhood, an equity criterion, which has an impact over human beings, is related to the quality of community life, i.e. the amount and the numbers of employees of neighbourhood associations. To evaluate the economic impacts on development, we can use the global cost criterion (by considering the costs of the products on the whole life cycle).

Rating scale	Environment	Economy	Equity
Site	• Water saving • Energy performance • ….	• Global cost • Maintenance cost • ….	• Thermal Comfort • Indoor installation quality • ….
Neighbourhood	• Energy management • Waste management • ….	• Unemployment rate • Local employment rate • ….	• public transport rate • associative life quality • ….

Table 1: Example of criteria in the two rating scales

3.2.2 Development criteria. The choice of criteria will be based on existing lists of criteria [Figure 2 (1)] and on the opinions of local actors in the construction field, questioned thanks to opinion polls [Figure 2 (2)]. A statistical analysis [Figure 2 (3)] will allow the development of a first list of sustainable development criteria [Figure 2 (4)] where each criterion has three possible

states: bad, medium and good. One or more datas and thresholds can correspond to the criterion.

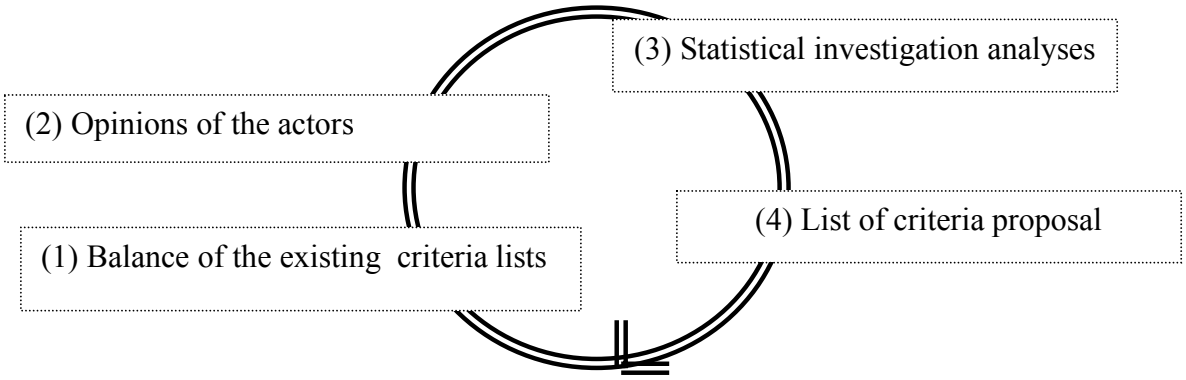

Figure 2 Development of the criteria list

For example, the thermal comfort criterion depends on the number of complaints, it is classified as follows [Table 2]:

- Bad state if the number of complaints is higher than 5 per month,
- Medium state if the number lies between 1 and 5 per month,
- Good state, if there is less than one complaint per month.

The thresholds are thus 1 and 5 for information numbers of complaints of the thermal comfort criterion.

Criteria	Bad	Medium	Goods	*States*
thermal comfort	Number of complaints > 5 per month ….	Number of complaints between 1 and 5 per month ……..	Number of complaints < 1 per month ….	*Information*

Table 2 Example of classification depending on the 3 states

The list obtained will be used as a discussion basis and will allow the first evaluations. It will evolve with the interventions and the opinions of the different actors questioned in order to be more representative of the opinion of the actors.

The evaluation will provide, in particular thanks to a graph, decision-making support for the choice of the sites where it is be necessary to rehabilitate and for the classification of sites. The example of graph results illustrated on Figure 3 can be analysed by the fact that too much importance was given to the economic criteria on the site whereas on the site neighbourhood, the balance between the "three E" is well reached.



Figure 3 : Graphic result example

3.3 Human living and technical diagnosis

At the same time that the searching for possible solutions is carried out, the building owner wishes to know if the problem concerns not only a technical insufficiency of the sites but also a particular social environment.

We set up an approach [Figure 4] which focus on the following points :

- *Characterization Problems* and identified solutions assessment.
- *Inhabitants investigation on the identified problems*. The investigation aims at detailing the problem sources and at identifying the provision of the tenants to accommodate the different solutions. This investigation is geared towards to the inhabitants, the foreman and the people in charge of customer service and work control.
- *The technical diagnosis* of the studied sites aims at determining the design features of the frameworks implied in the search for solutions.
- A *multicriteria analysis* relying on the existing solutions. The characteristics of the inhabitants and the diagnosis of each site will make it possible to offer for each site a set of the best solutions.

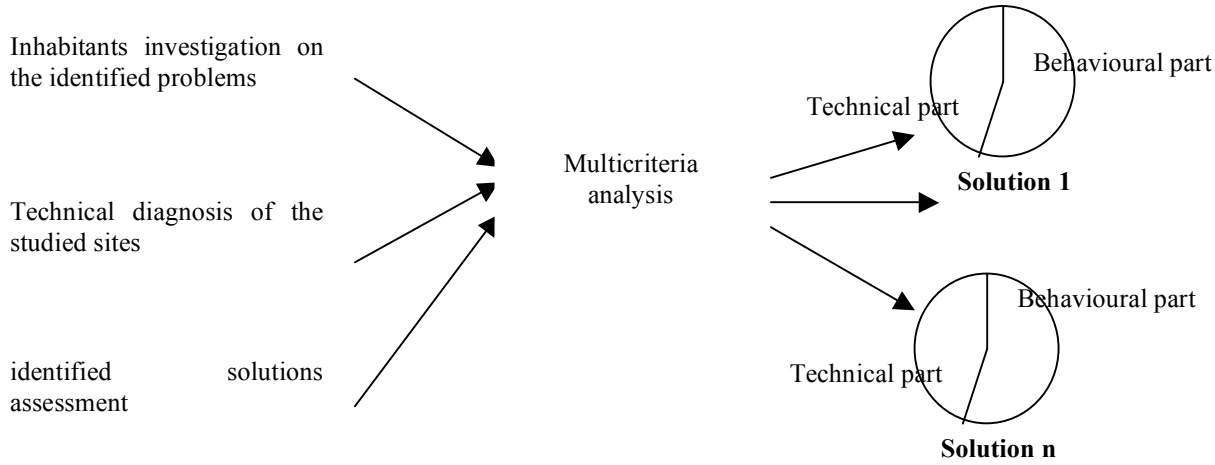

Figure 4: Diagnosis presentation

3.4 Choice of solutions and quality of life improvement

The following phase consists in proposing a set of solutions resulting from a behavioural and technical compromise focusing on the site which has the best sustainable value. The solution should be the best for the tenants and the social building provider too.

This compromise will take into account the problems posed:

- A building dysfunction,
- An insufficiency of the components of the building,
- behaviour inhabitants and/or "socio-differentiated" perception of the problems.

4. CONCLUSION AND WORK IN PROGRESS

The research work has presented a general methodology which will allow the social building provider to structure his actions and to set up solutions which take into account the human being. The current application of this approach concerns the sound harmful effects (inconvenience revealed in council flats and where a multicriteria approach is necessary). This application is being carried out by the Pas-de-Calais habitat on 9 sites of its heritage. For those nine sites, we will evaluate their sustainable development value and we will carry out a close investigation with the tenants. A set of acoustic measurements is in progress in Pas-de-Calais habitat sites and it will evaluate the acoustic performances of those residences. The conclusions of this work will lead to an experimentation on one of the sites in order to validate the approach or to improve it.

5. ACKNOWLEDGEMENTS

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Experimental Centre for sustainable housing Technologies

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1. INTRODUCTION

An International Design Ideas Competition, with the theme *Sustainable Housing for the Poor*, held in 1995, and co-sponsored by ANTAC - Brazilian Association of Technology for the Built Environment and PLEA - Passive and Low Energy Architecture, indicated some project guidelines and technological alternatives related to the principles of sustainable design for low cost settlements. A research project has, since then, been conducted with the aim of summing up the main ideas awarded in the competition, through the implementation of a centre for experimentation, demonstration and environmental education – the Experimental Centre for Sustainable Housing Technologies (Sattler, 2000).

In February 1999, a contract was signed between NORIE/UFRGS, a post-graduate group working at the Department of Civil Engineering of the Federal University of Rio Grande do Sul, Brazil, and the municipality of Nova Hartz, located in the metropolitan area of Porto Alegre, southernmost capital city of Brazil, aiming at the development of an executive design for the Experimental Centre for Sustainable Housing Technologies – CETHS. Since then, several actions have been accomplished to implement CETHS in this municipality. A few months later, an area of 2,3 ha, was presented to NORIE for the implementation of CETHS. One initial challenge was the fact that this area had, at that time, an approved design for its urban infrastructure. The research group had, then, to adapt the existing design in order to make it more in accordance to sustainable principles. All the projects were rethought and reformulated seeking the minimum environmental impact. This paper presents some of the guidelines adopted for CETHS conception and implementation.

2. MAIN GUIDELINES FOR CETHS

The proposals for the new urban infrastructure for CETHS (Figure 1), can be said to be related to:

- Urban design;
- Management of rain and waste water;
- Establishment of guidelines for new building prototypes;
- Urban agriculture and productive landscaping;
- Use of sustainable energy sources.



Figure 1: CETHS general proposal.

2.1. Urban design proposal

The design proposal aimed at a modification in the relationship among the elements that make up an urban landscape – human being, building, automobile, vegetation, infrastructure – transforming the street in a place that increases the possibility of community integration. In general, settlements are produced to privilege the automobile. The fact results is partly due to the legislation that establishes a required minimum width, that in general is far greater than the needs of residential settlements.

In the design of CETHS, the main assumption was to give priority to people as well as to their interaction. With this purpose the local streets width was diminished, and given only one direction of traffic. By doing so, the sidewalks could be enlarged and it was possible the creation of some pockets for locating urban equipments. Straight lines streets were also abolished, resulting in traffic speed reduction, thus allowing people to walk and live more peacefully (Figure 2).

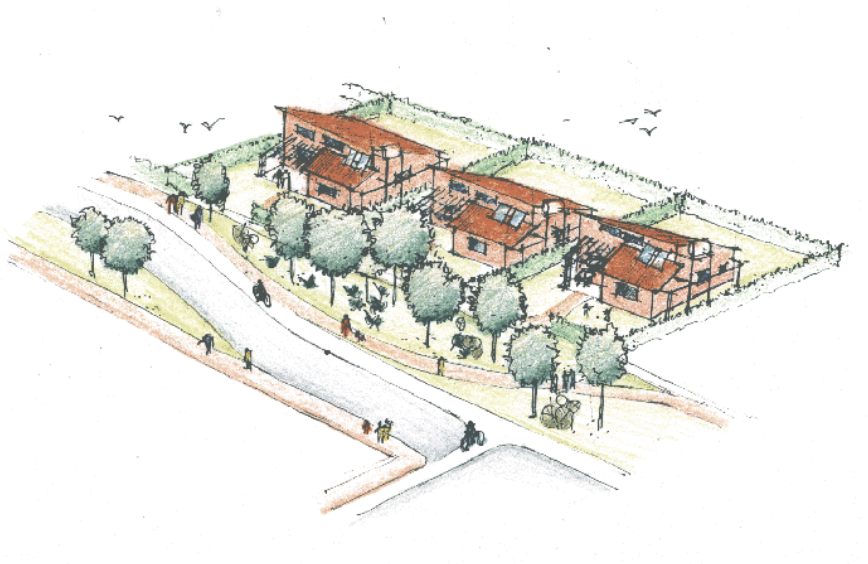

Figure 2: CETHS landscape.

The design also aimed at an cooperative integration of the different elements that make up the landscape, in such a way to associate each element to more than one function, maximizing the use of the resources. The street, for example, can, in some circumstances participate in the flow of rainwater. A bikeway may work together with the street, creating space for the flow of larger vehicles.

2.2. Management of rain and waste water;

Presently the city of Nova Hartz is supplied with underground water, from individual wells, as there is not a water treatment plant in the city. The same alternative should be implemented in the Experimental Centre for Sustainable Housing Technologies. Once a healthy supply is identified, water should be pumped into a cistern, with the aid of a wind turbine, this in association with a conventional pump for days without or with little wind.

Liquid residues generated in the buildings were classified, according to their characteristics as black waters (toilet water) and gray waters (kitchen, shower water). For both, the guiding principle is of considering residues as resources. This way, black waters will be directed into an anaerobic unit, where three products will be generated: biogas, sludge – that will added to composting piles, to improve soil quality in landscaping – and liquid effluent – that will end in an aquaculture pond and produce biomass and fish protein (Figure 3). As many steps (sand filters, reed beds, flowforms, small basins) as necessary will be included in the liquid effluent destination in order be sure of the quality of water in the aquaculture pond.

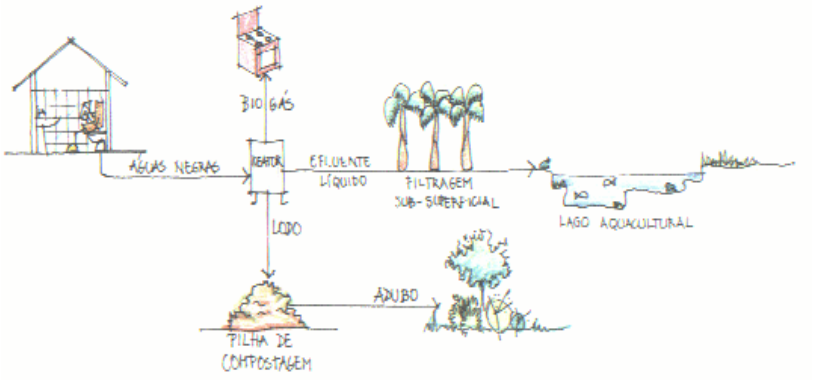

Figure 3. Black water managment

Grey waters after getting rid of grease, will be filtered and, as far as possible, used inside the plot. For rainwater the strategy is to “work with nature” (Lyle, 1994), letting it be filtered through the ground, adopting permeable paving (Figure 4).

2.3. Guidelines for new building prototypes

The guidelines for new building prototypes will follow Sachs (1993) dimensions for sustainability:

- Social sustainability will be sought through houses that provide quality of life to low income people, making possible to live with dignity. The aim of the design should be the production of housing so to provide well being to the householder and not to produce a house at minimum cost, only;

- Economic sustainability is related to initiatives that seek cost reduction and local provision of income. The proposals are:
    - use of local materials, reducing transportation costs and provide local jobs;
    - reduction of construction wastes;
    - self-building schemes, giving opportunity for acquiring new skills and making participants more committed to the project, thus increasing the opportunities for social;
- Ecological sustainability can be reached through:
    - responsible choice of materials and constructional systems, considering the environmental impacts associated to options made;
    - optimization of the environmental performance in the use phase of the building, mainly through the use of passive systems of environmental control and use of clean and locally available sources of energy;
    - awareness of topography and existing ecosystems
- Spatial sustainability is defined by the architectural typology that is proposed. It should present the following characteristics:
    - compacity, as the land availability is limited, thus releasing land for food production;
    - flexibility, that allows for a better suit to the functional needs of the user and enrichment of diversity in the composition of the urban environment;
    - use of a formal solution that does not cause conflicts among householders, thus contributing to community dispersion;

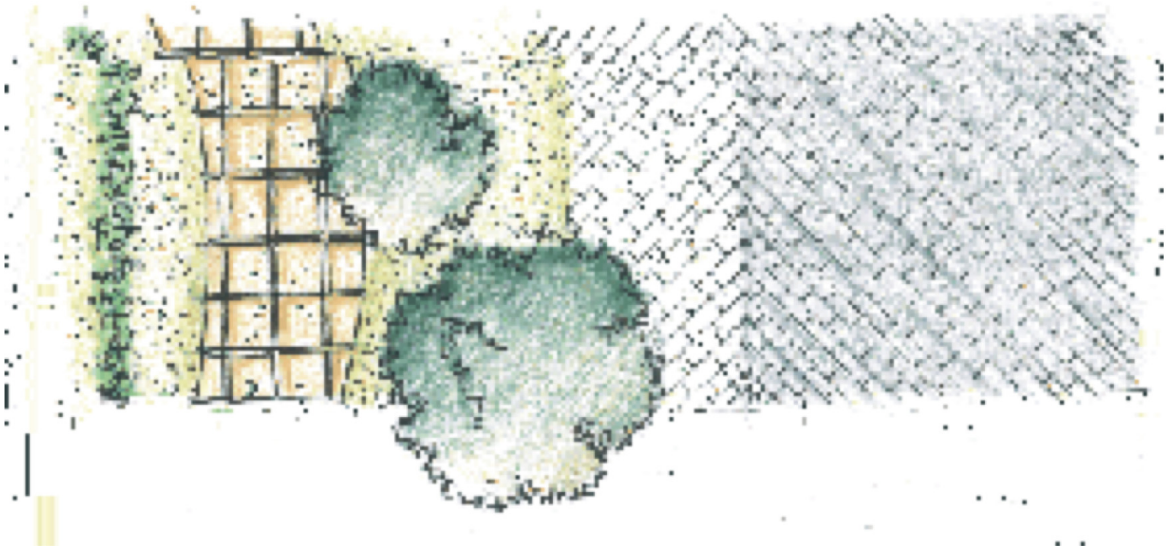

Figure 4. Permeable pavement.

- Cultural sustainability will be sought by:

- identification of those elements in buildings that integrate the “affective memory” of the community;

- identification of building spaces that support and stimulate activities and behaviors that are typical to the communities.

2.4. Urban agriculture and productive landscaping

CETHS should have, when totally implemented two food production systems: individual production in each housing plot and a collective production area. Both will follow permacultural principles (Mollison, 1992). It is expected that vegetation will aggregate the maximum number of function possible, including productive and pedagogical functions. The production function will be achieved through species whose products could be used directly by the householders (directly consumed or as preserved food), by animals (converting vegetables into animal protein) or by the local fauna; or be used as biomass, sustainably managed. The pedagogical function will be achieved by a participatory decision to choose which species will be used, allowing the local public know *what* they are planting, *with which purpose* and in which extent they will improve the environment, nourish them and provide them a better health condition.

Other functions performed by the species to be chosen, include those of improving the physical environment, providing thermal comfort (both in each dwelling and in the whole settlement) and of improving psychological well being, considering the peacefulness and the relaxation determined by vegetation. In that sense, not only the visual characteristics of vegetation will be explored, but the whole set of sensorial connection with nature (like taste, touch, smell and hearing).

The way of collectively produce food will be decided by the community itself, with the aid of a social work to be developed by the municipality of Nova Hartz. The project proposal is that the production from the area should supply the local families, together with the local community center and kindergarten. Any excess could then be sold by the community.

All production is expected to follow the principles of sustainable agriculture: using local resources (including labor), organic compost, valuing biodiversity, promoting interaction between productive animals and crops, looking for alternatives to chemicals.

2.5. Use of sustainable energy sources

Although, due to its characteristics of a low cost settlement, some of the sustainable energy sources cannot be immediately afforded by the scheme, some other were considered for CETHS, for example, the use of solar collectors for water heating and use of biomass to be burnt in cookers, for food preparation and environment and water heating in winter.

At the moment, the potential for wind energy use is being assessed by means of a research project being developed in a joint cooperation with the Secretary of Energy of our State, where wind speed and direction is being monitored, by a M.Sc. student.

3. FINAL REMARKS

This article has characterized the Experimental Centre for Sustainable Housing Technologies in its several aspects. At the moment, 8 houses were built (Figure 5), from a planned total of 49 units. The last activities are related to the process of having all the proposed ideas approved by local authorities. This experience made explicit all the difficulties associated to the approval of projects with innovative proposals, even though those are based of previous successful experiences and lessen environmental impacts. It is hoped, nevertheless, that CETHS could represent a future reference to the design process and implementation of low cost housing settlements in Brazil. In order to achieve this, the whole process, starting from the initial stages, is being well documented and publicized, both through the midia and in scientific meetings. This way, through the documentation of the process, the training and qualification of students and professionals linked to the design and implementation of sustainable housing settlements will be made possible, as well as the exchange of experiences with other municipalities, universities and research centres. The inhabitants' understanding of environmental issues is of upmost importance for the success of CETHS, as it represents a new life proposal, with the goal of minimizing the impacts to the ecosystem, looking for a cultural, social, economic and environmental compromise.



Figure 5. View of CETHS (March 2002)

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Electrical Energy Consumption Patterns in different Types of Residential Buildings in the City Porto Alegre, Brazil.

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1. INTRODUCTION

This paper intends to discuss further the of the data presented in a previous paper (Hansen and Sattler, 1991), regarding electric energy consumption in a Brazilian city. The above, as well as the present, data resulted from a MSc dissertation research work, conducted by one of the authors, where the electrical energy consumption of ten different types of buildings was analysed. The research showed that the factors determining such use of energy are very complex and varied, as they involve many variables, including: type of users and their social class, type of appliance used and length of time of use and consumption habits. Most of these variables are very difficult to be characterized, as some of them require thorough surveys. Nevertheless, their understanding, and the verification of their relationships, is extremely important for design actions, both for supplying demand and for the optimization of the use of electric energy.

2. SURVEY

Electrical energy consumption and consumption patterns were surveyed in an area located in the southern region of the city of Porto Alegre (30°01'S; 51°13'W), southernmost capital city of Brazil. The municipality of Porto Alegre has an area of 476.3 km^2 (47,630 ha) and a population of about 1,360,000 inhabitants (in the year 2000). The area that was surveyed has about 1,500 ha. and 155,000 inhabitants.

The total of electrical energy consumed in the city in 1998, in the residential sector, was 1,121,213 MWh, with peaks of 103,652,000 MWh, in January (summer highest), and 100,980,000 MWh, in July (winter highest). The average *measured* residential electric energy consumption in the period 1997-1998 was of 225 kWh/month (Hansen, 2000).

Considering a larger scale, it is worth mentioning that the residential sector, in Brazil, is responsible for more than 24% of the total electric energy consumed in the country (Lamberts, 1996), and that most of this demand is to supply large urban centers. The Brazilian average consumption, per inhabitant, is about 170 kWh/month, considering the total of all sources of energy and all types of use.

The studied area shows 19 morphological zones, including areas presenting specific attributes such as: kind of land plots, building type and state of conservation, construction density, land use, trends of change in land use and building rates. The studied area was chosen due to its variety in residential characteristics, presenting different types of buildings, that are occupied by very different social classes, representing equally differentiated socioeconomic groups.

From the analysis of the morphological zones of the studied area, ten different types, those that are more often present in the studied area, were identified and classified, seven of them being single family households and three, multifamily households (Fig. 1):

- Type 1 includes one-storey masonry houses, having simple finishing, being part of low-income housing schemes;
- Types 2 and 3 include small one-storey buildings, having a rectangular plan, being quite old and having a front balcony, with wood or mixed finishing, for type 2, and masonry finishing, for type 3;
- Type 4 households have one-storey, masonry finishing, occupying the whole land plot frontal area; their ground plans being rectangular or "L" shaped;
- Types 5 and 6 have good quality masonry finishing, two floors, compact shape, for type 5, and irregular shape, for type 6;
- Type 7 includes one or two floors detached houses, settled on large land plots (nearly 1,000 m^2, on average);
- Type 8 includes four storey housing blocks, having plain external finishing and rectangular shape, gathered in housing complexes;
- Type 9 include three to five storey buildings, including penthouse, and follow good quality standards;
- Type 10 includes tall (12 to 15 storey) buildings, with penthouse, built on piles.

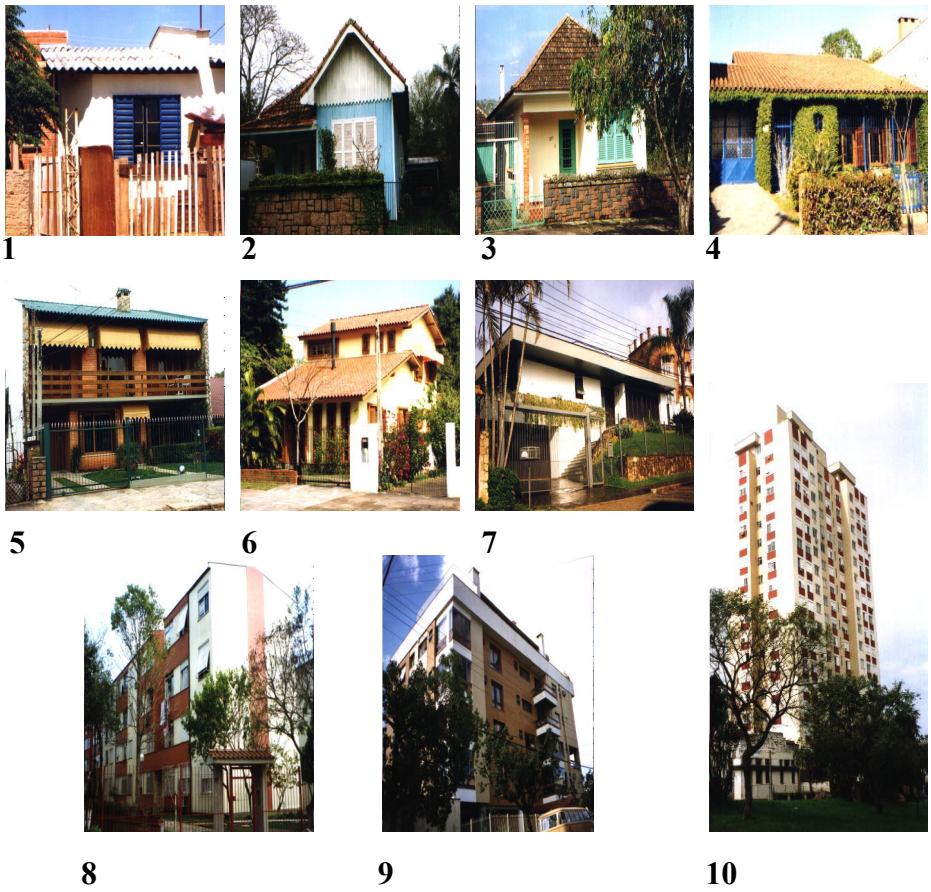

Figure 1: Identification of the types of buildings studied.

Electric energy consumption data, concerning two years (1997 and 1998), for all the households surveyed were obtained with the electricity supplier (CEEE, 1999). A three-section

questionnaire was prepared for a field survey. The first part included general questions on: built area, land lot size, family size and income, etc. The second part included questions on number and use (number of hours switched on) for each household appliance; including number, type, and use of artificial lighting. Over 30 (thirty) households were diagnosed for each type of building, totaling over 1% the local population (approximately 1,500 persons).

The collected data were tabulated, not only to verify the electric power final use, but also to compare the data obtained on the survey to the real consumption data. Estimated (from questionnaires) and real (measured) biannual monthly average consumption, for each building type, compared very well, its correlation being 0.92. As some household appliances are differently used in summer, winter or spring/fall, due to the seasonal variations in the local climate, it was necessary to separate the consumption estimates, concerning the use of the household appliances, during the three different periods of the year, to obtain the estimated total average consumption closest to the real rate.

3. RESULTS AND DISCUSSION

3.1. Electric energy consumption and building types

The most frequent (39 % of the consumers) energy consumption values were found to be between 151 and 300 kWh/month, while the average consumption per household was 350 kWh/month. A higher consumption was verified in types 4, 5, 6, 8, 9 and specially in type 7, during winter and summer months, mainly because of the use of air conditioners and fans (Fig. 2).

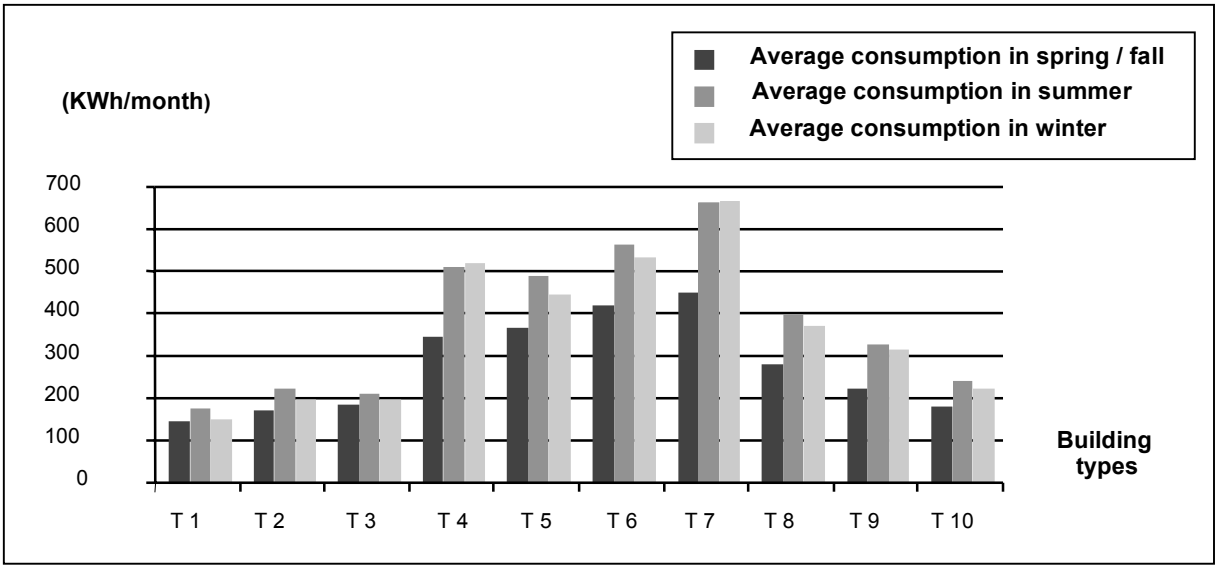

Figure 2. Estimated average consumption, per building type, for three different periods of the year.

3.2. Household appliances and final electric power use.

A great increase in the number and diversity of household appliances was verified when comparing different building among types 1 to 7, although that was less evident among building types 8 to 10. Although a reduced number of essential household appliances is used in buildings type 1, it was possible to detect that 78% of the households have electric fans for summer ventilation. From buildings of type 2 to 7, the number of appliances used for improving environmental comfort (fans, air heaters and window and central air conditioners) increases, both

in winter and summer. It was also verified that the number of TV sets increases from 1.9 to 2.9 per household, when comparing the buildings of type 3 and type 7.

Electricity final use is mostly directed to water heating, refrigeration and lighting, in buildings of types 1, 2 and 3, but also applied to air conditioning in buildings of types 4, 5, 6, 7, 8 and 10 and to dish and clothes washing in building type 9 (Figure 3)

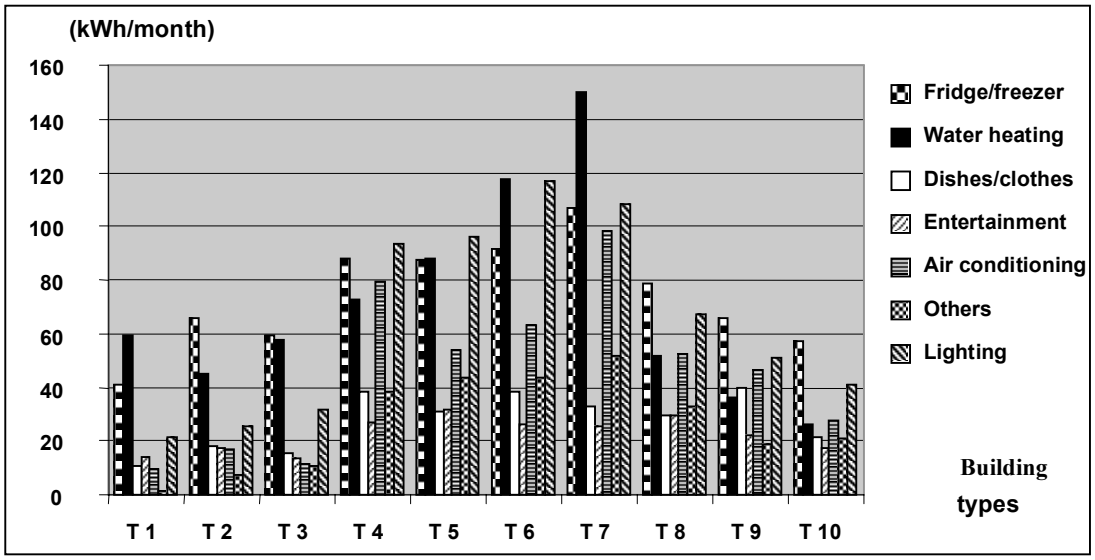

Figure 3. Electricity final use in the different types of buildings.

3.3 Other results concerning energy consumption and building types

The number of inhabitants is nearly the same in all types of buildings. An average of 3.7 inhabitants/household was found. It can be verified, in Fig. 4, that the energy consumption per square meter was higher in the building types having smaller built area.

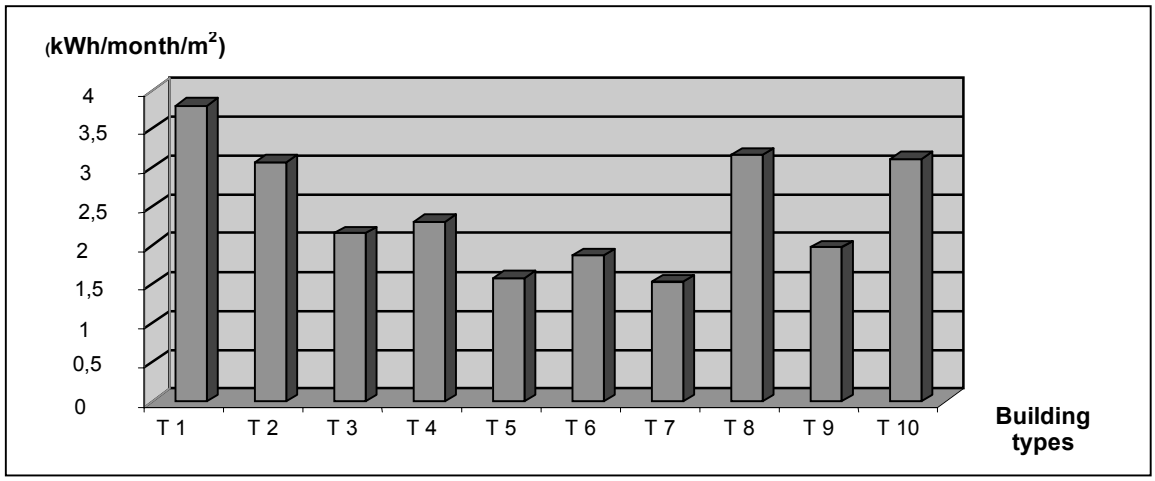

Figure 4. Consumption per square meter in the building types

Considering all types of buildings, the estimated monthly average consumption per inhabitant was 93.6 kWh/month/inhabitant. Figure 4 shows that the estimated average consumption per inhabitant increases gradually in steps of about 25 kWh/month. The first step, refers to building type 1, with approximately 40 kWh/month/inhabitant; the second, refers to types 2 and 3,

with approximately 65 kWh/month/inhabitant; the third, represented by types 8, 9 and 10, with approximately 90 kWh/month/inhabitant, the fourth represented by types 4, 5 and 6, with approximately 115 kWh/month/inhabitant, and the fifth level, by type 7, with approximately 140 kWh/month/inhabitant.

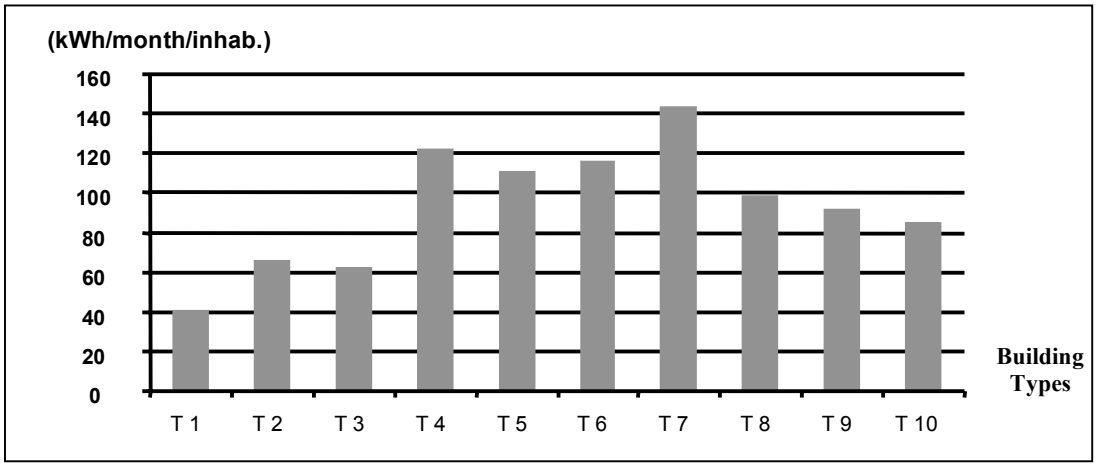

Figure 5. Estimated monthly average consumption per inhabitants in the different building types

It was verified that 3.4% (11 houses) of the households use electric boilers to heat bath water in types 4, 5, 6 and 7, and 1.5% (5 houses) of the households use this kind of equipment to heat bathroom and kitchen water, but are not provided with timers, causing a very high energy consumption at these households. It was also verified that only 0.9% (3 houses) of the surveyed households have solar collectors for water heating (in types 6 and 7), using hot water for the bathroom and kitchen. Coincidentally, these also show the highest values in energy consumption among all the houses.

In order to check how the houses perform in terms of electrical energy consumption, a comparison was made (Table1) between the average consumption, in each type of the Brazilian houses, and in some other reference houses in Europe, including three types of houses of very high performance.

Looking at the values on Table 1, one could say, at a first glance, that the Brazilian houses are performing well when compared to some "high performance" buildings, as are the buildings designed by Robert and Brenda Vale and the one, by the UCL/Belgium team; particularly when comparing values of energy consumption per square meter. But you immediately realize that, as the floor areas are quite different, this is not the best index for comparisons. Nevertheless, one can see how high the electricity usage is in those chosen for comparison, in particular in a house designed to have a high performance in terms of energy consumption, like the Maison PLEIADE, when compared to the Brazilian counterparts.

It must be stressed that, while the European values of energy consumption are mostly due to lighting, and use of laundry and kitchen appliances, the values associated to the Brazilian houses include those above - see Figure 3 -, **in addition** to space cooling and heating, and water heating (the latter, identified in the figure as *water heating*, is mostly performed by electric showers). The use of electric showers is the main cause for the daily peak in demand in Brazil – in building types 1 to 3 more than 94% of the households use them for showers; this percentage decreases to 75% in building types 4 and 6; is about 60%, in building types 5, 9 and

10 and about 45%, in building types 7 and 8). On the other hand, it is also worth noting that, just for space heating (gas) the typical UK house requires another 146 kWh/ m^2; the Cresswell Road houses 32 kWh/ m^2 ; the Maison PLEIADE, 44 kWh/ m^2; and the autonomous house, 13,3 kWh/ m^2.

Table 1 Electric energy consumption in various households.

Houses	Electric energy consumption (kWh/m^2/year)	Total area of the house (m^2)	Electric energy consumption (kWh/year)
1. Maison PLEIADE	39.8[1]	180	7,164
2. Autonomous House	17.5	176	3,073
3. Cresswell Road	26	88.2	2,293
4. Typical UK house	28	88.2	2,470
5. Porto Alegre (average values)			
Type 1	37.5	40	1,500
Type 2	33.7	68	2,292
Type 3	26.5	100	2,652
Type 4	28.0	187	5,232
Type 5	20.8	280	5,820
Type 6	24.0	274	6,576
Type 7	18.4	418	7,692
Type 8	33.2	122	4,056
Type 9	24.2	140	3,396
Type 10	36.4	68	2,472

Notes:
House **1**: data taken from De Herde, A et al, 1998; Houses **2, 3 and 4**: data taken from Vale, B. and Vale, R., 2000.
[1] Space heating with natural gas.

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A low Cost sustainable House

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1. INTRODUCTION

A research contract has been signed between the Federal University of Rio Grande do Sul and the municipality of Nova Hartz, city located in the metropolitan area of Porto Alegre, southernmost capital city of Brazil, to develop studies regarding the design and construction of a sustainable community, incorporating the design and construction supervision of 8 low cost houses (Sattler, 2001). Several sustainable issues were considered in the design of the houses (Figure 1), that were still under construction when this paper was submitted (Figure 2): passive strategies for heating and cooling; use of local and low environmental impact materials; possibility of self-construction; use of sustainable energy sources; local management of solid and liquid household wastes; domestic production of food.



Figure 1. View of the Alvorada low cost house, as designed.

Other two houses of the same type are now being constructed: **one** in the city of Alvorada, also in the metropolitan area of the city of Porto Alegre– for whom the prototype was initially devised and giving its name to it – but that only now are starting to be build, and the **second**, in the university campus, this as an experience of self building, where about twenty undergraduate and post-graduate students participate in its construction (Figure 3).



Figure 2. View of the Alvorada low cost house, as built in the city of Nova Hartz (March 2002).



Figure 3. Students joining in the construction of a prototype at the university campus (March 2002)

The house itself and the several sustainable issues adopted will constitute a prototype for the later implementation of a larger research project, that will include the construction of 49 sustainable units, as a small sustainable community (Sattler, 2001).

The sustainable house was designed in such a way to incorporate production spaces both indoors and outdoors. Production outdoors will be aimed at the production of food, following the principles of sustainable agriculture, seeking for human's health and environmental preservation. By indoor production we mean the creation of some sort of income for the future residents. The building as a whole is intended to become a site for demonstration of sustainable technologies related to buildings. The paper describes the house, a 45 m^2 unit, and the several related sustainable strategies being envisaged.

2. GUIDELINES ADOPTED IN THE CONCEPTION OF THE PROTOTYPE UNIT

Considering the characteristics of the city of Nova Hartz (population around 15,000, economy based mostly on the leather shoe industry, beautiful landscape at the foot of a mountain range) and its the surroundings, as well as of the available technological alternatives, a preliminary study was developed, following the guidelines below:

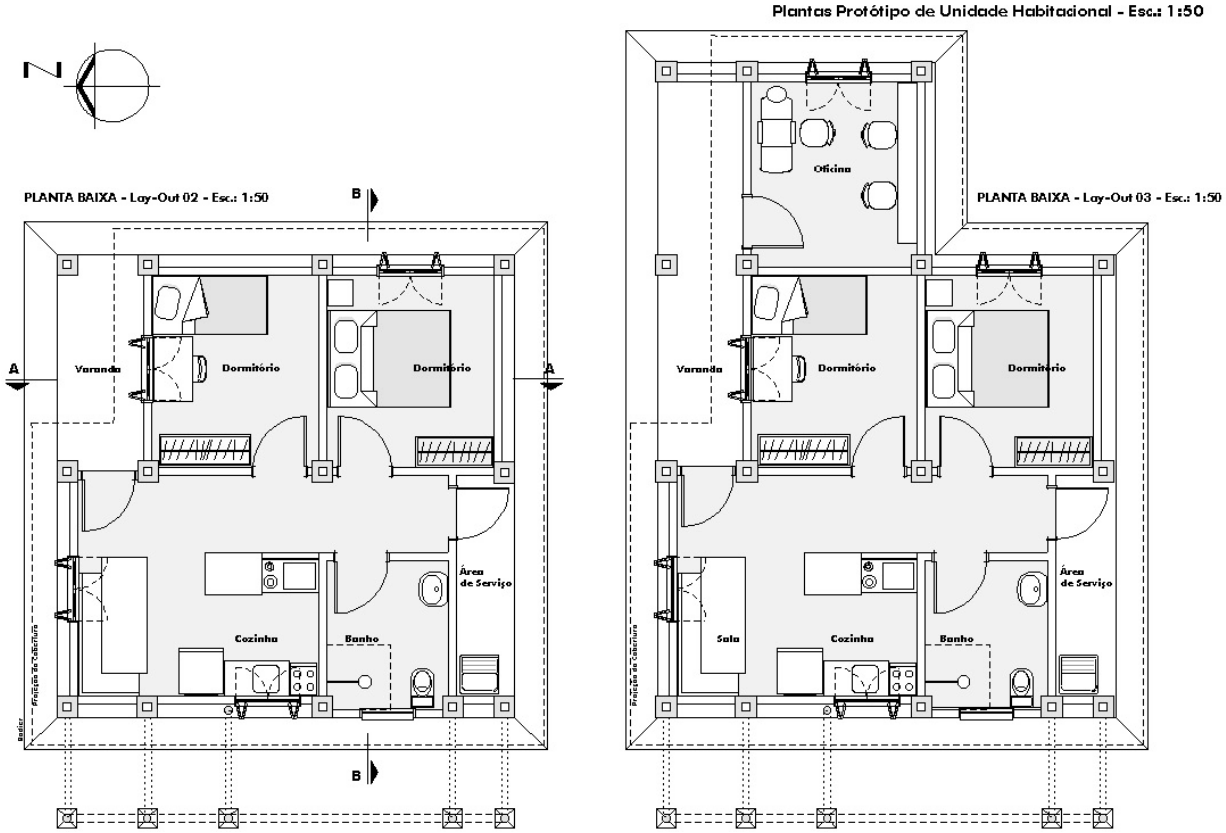

Figure 4. Plan of the house showing the standard plan (left) and the extended one with a working space (right).

- To develop the proposal in the direction of the optimisation of its functional capacity, postponing the cost and consumption assessment to a later stage in the design, when introducing the necessary corrections. Although simple in principle, this guideline signifies a radical change in the way of dealing with low cost housing in Brazil, where the traditional approach has been of reducing costs at the expense of a sharp reduction on living spaces (20 to 30 m^2 for a whole family) and on the quality of the built product.

- To specify materials in agreement with the principles of sustainability, considering the minimization of environmental impacts in their whole life cycle. This aspect is particularly important as the observation of the constructional typologies of the region has shown that local people associate high quality housing to the use of wood and ceramic, both locally available in the region and less damaging to the environment than other types of construction.

- To make allowances for handicapped people in the project. The cost minimisation in the housing production has led to a corresponding reduction in the size of the built spaces. If the reduced spaces create difficulties for those with normal locomotion abilities, they virtually confine handicapped people to a sort of home prison and to a total dependence on the help by others for the accomplishment of the trivial daily activities. The prototype design proposal is to improve the built spaces to the whole of the potential users and, in particular, to retrieve the quality of life and production capacity of handicapped people.

- To use the resources of bioclimatic architecture to produce spaces offering healthy internal spaces and optimised comfort conditions, with no dependence of active systems for cooling and heating. The search for design solutions for the house envelope, mainly for the openings, allows for an improved energy budget. Its association to solutions like cross ventilation, create environmental comfort conditions that are far superior to those found in the traditional housing sector, without demanding any additional energy supply.

- To use technologies that can be easily appropriated by the users, in such a way that they really can become effectively practised. Furthermore, the techniques employed in the construction must be simple enough to allow their use by self building processes.

- To design the prototype considering the conditions of the site where it will be built. The prototype should be integrated to the local institutions and allow the development of activities that attract the different representatives of local communities. Being a prototype the building should constitute a reference for environmental awareness among the population. As such it can house activities for diffusion of sustainable technologies, in close relationship with other environmental initiatives.

- To include a space that will work as a potential source of income in the house programme (Figure 4). This possibility of work, in association with the living space, becomes of fundamental importance once related to people of very low income and only marginally linked to the formal working class. The incorporation of an income generation space in the programme of a sustainable house allows for a better solution for housing production, by taking into account the income generated in this space for the payment of the corresponding mortgage.
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3. SUSTAINABLE TECHNOLOGIES INCORPORATED INTO THE PROTOTYPE

Several sustainable technologies were incorporated into the design of the low cost house prototype. Those were selected from their presumed acceptance and facility of implementation by the future users:

- **Use of rainstorm water** collected by the roof, stored in tanks built with simple and cheap materials, close to the bathroom, for supplying only the flushing of the toilet. Although the designers aim at composting toilets, they understand that more time is required to

make them more widely acceptable and that perhaps a better strategy will not be to start testing them with very low cost houses, as their users might find difficult to understand its environmental implications and feel deprived of the comfort of the traditional toilets, deeply institutionalised among the higher classes in the society. It is believed that this strategy alone, the use of rainstorm water for flushing toilets, might result in a reduction of more than 40% of treated water consumption.

- **Biological treatment of waste water** through the combined use of septic tanks, sand filters, reed beds and aquacultural ponds. Although, due to a scale problem, only the three first of these strategies might be applied to one prototype, it is very likely the construction of other units by the municipality of Nova Hartz on the same site, so that the permacultural pond may also be built on the site.

- **Solar energy collectors for water heating**, based on cheap and economical equipment. The proposal is to use the heated water for the shower, mainly, replacing the traditional system in Brazil of using electrical showers for water heating. It is estimated that the electricity consumption reduction will be around 30%.

- **Landscaping with productive plants.** The proposal is to shade the west façade of the building with vines, that allow the solar radiation penetration during the cold season. This strategy would allow, at the same time the production of fruits for consumption by the users.
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4. CONCLUSION

This paper summarises the working strategy for the design of a low cost sustainable house in Brazil. One of the main challenges was to define what a sustainable house is, considering the specific conditions related to the prototype to be built, instead of a simple stereotype that could be applied to any situation, anywhere on the planet.

In practical terms, this asked for a series of studies to solve some questions related to the necessities to be supplied by the house, in the specific context where it is being built, in addition to other, asking for technological issues in compatibility with the preservation of the environment. The failure in the solution of the latter questions would jeopardise the sustainability of the proposal and of the former, would mismatch the constructed building from its function as a house.

Along the studies, the design team was always aware that the results of the investigations could not replace the house users opinion. This justifies the materialisation of the proposal as prototypes, a real scale sample of the technological solutions that the design team is implementing in the CETHS housing settlement, to be understood and criticised by the local community people. This way, it is hoped that the efficacy of the solutions become confirmed, as well as their acceptance and appropriation by the future users.

The basic assumption is that the CETHS future users, by contributing to the enhancement of the house proposal, may appropriate not only the demonstration building, but also all the ideas incorporated in it, in particular those related to the possibility of living in a healthy environment without abdicating the benefits enabled by modern technology.

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Wall Systems made of Renewable Resources

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INTRODUCTION

Beside a good marketing concept, the successful introduction of new products into the building product market is dependent on technical certification. The aim of this project is to guide the innovative straw bale building method from the experimental stage to the professional stage, and to support its market introduction by providing the necessary product certificates, tools for efficient and effective quality management and optimized constructions suitable for passive houses. To achieve this, research and development work has to be done on three different levels:

- Developing technical tests to provide fire resistance and heat insulation certificates to meet the criteria set down in the Austrian and European Building Codes
- Optimising straw bale wall systems and connections of building components
- Developing a mobile straw bale testing lab to provide a tool to ensure efficient and effective quality management from the field to the straw bale house

THERMAL INSULATION TESTS

The post and beam straw bale construction used in the project was tested at the research institute of the MA 39 in Vienna and led to some exceptionally good results concerning heat insulation and fire resistance.

Thermal insulation of straw bales had already been tested in the USA. From these results a specific heat conductance of about ([lambda]; SI-unit: W/mK) 0,05 W/mK was expected. This would allow for a [lambda] of 0,06 W/mK taking into account the 20% humidity supplement for organic materials provided in Austria. The actual test results showed an even lower specific heat conductance of [lambda] = 0,0337 W/mK and 0, 0380 W/mK. With the 20% humidity supplement, straw bales have a [lambda]value of 0,0404 W/mK and 0, 0456 W/mK
The first value was measured according to ISO 8301:1991 (Thermal insulation - Determination of steady state thermal resistance and relate d properties - Heat flow meter apparatus), the second one according to ÖNORM B 6015 Teil 1 (Determination of thermal conductivity by the guarded hot plate apparatus).
These test results confirm the high performance of straw bales in terms of heat insulation.

FIRE RESISTANCE TESTS

The fire resistance of the building material (straw bales) and the building component (the straw bale wall system), was tested. Building materials are classified into four different groups:

A not inflammable, B1 hardly inflammable, B2 normally inflammable, B3 easily inflammable

To be able to use building materials without legal restrictions, a B2 certificate is needed.
Building components are classified into F30, F60 and F90, which implies how many minutes the building component resists fire. Tests already carried out in the USA led to the conclusion that the lack of oxygen in the compressed straw bales is responsible for a high fire resistance. This conclusion was confirmed by the tests carried out within the scope of the project. The straw bale and the straw bale wall system were tested according to ÖNORM B3800.
The straw bale was classified as B2 and the tested straw bale wall system was classified as F90.
These excellent test results show that highly fire resistant constructions can be realised without chemical treatment of the straw bales.

BUILDING PHYSICAL CALCULATIONS AND OPTIMISATION OF STRAW BALE CONSTRUCTIONS FOR PASSIVE SOLAR HOUSES

The avoidance of sources of error and the optimisation of building junction elements is essential to guarantee the high functionality of the products used and to ensure passive house standards in the long term. To this end 8 different wall systems based o n the post and beam straw bale wall (wooden framework construction with straw bale in-fill) were developed further and optimised.

Construction 1: Straw bale wall, outside ventilated at rear, interior gypsum plaster board
Construction 2: Straw bale wall ventilated at rear, interior clay plaster
Construction 3: Straw bale wall ventilated at rear, interior Hourdis brick
Construction 4: Straw bale wall ventilated at rear, interior clay board
Construction 5: Straw bale wall plastered, interior gypsum plaster board
Construction 6: Straw bale wall plastered, interior clay plaster
Construction 7: Straw bale wall plastered, interior Hourdis brick
Construction 8: Straw bale wall plastered, interior clay board

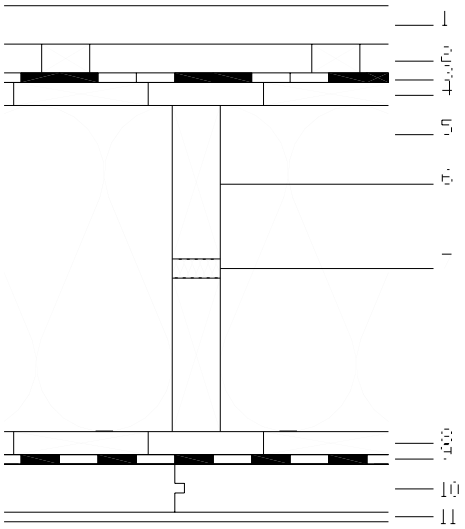

Figure 1 Construction 4 – Straw bale wall ventilated, clay panels on the inside

Table 1 Structure of construction 4

1	Shuttering	2 cm
2	Wooden bracing 4/4	3 cm
3	Wind barrier	0,02 cm
4	Wooden bracing diagonal	2,4 cm
5-7	Straw bale layer / wooden frame	34 cm
8	Wooden bracing diagonal	2,4 cm
9	Vapour barrier	0,02 cm
10	Clay panels	5 cm
11	Clay plaster two layers, reinforced	1.5 cm

Table 2 Building physical indicators of construction 4

Bauphysics - construction	Unit	
Thermal transmittance U-Value	W/m²K	0.13
Condensation/dry out potential	kg/m²a	
Straw bale insulation layer		0/0
Wooden frame		0/0
Heat storage capacity interior	kg/m²	66.8

All constructions fulfil passive house standards. Available calculations of thermal storage capacity to avoid overheating show low to middle values. The diffusion-open constructions avoid humidity problems within the wall and even enable fast drying after unexpected water damage. Sound insulation can be sufficiently achieved using double shell construction. Single shell constructions still have to be optimised. All the constructions exemplified can be made airtight without problem. Fire resistance is F90 without further adaptation. The connection of the straw bale wall to the other building components can be realised without creating thermal bridges. Installation of water and electricity causes no damage to the airtight layer. Joints of the straw bale to windows, ceiling and cellar can fulfil passive house standards.

QUALITY MANAGEMENT AND DEVELOPMENT OF A MOBILE TESTING LAB

To ensure the top quality of the building straw an efficient and effective quality management process has to be built up. To this end the development of a mobile testing lab for straw bales is the first major step. The testing equipment is responsible for the analysis and assessment of the quality of the straw bales. It also allows for the measurement of all relevant parameters of the bales. Dimensions, weight, temperature and humidity are measured. Furthermore, colour, shape, homogeneity, purity of the bale and appearance of mould are analysed and assessed by the testing person. The measuring equipment fits into a specially developed suitcase. A lab test series led to the adaptation and optimisation of the measuring equipment and allowed its functionality to be checked. The lab provides a reliable and easily applicable testing tool for the whole process, from the field to the straw bale house.

An important point of quality management is the avoidance of pest infestations during the storage of the bales and the building's construction. Literature points out that mice and insects are not a problem if straw bale constructions are properly made. It is also stated that clean straw has a low allergic potential.

It is important to use high quality bales and proper constructions also because badly

constructed buildings and the use of humid straw bales, or permanent penetration of water into the wall can cause mould growth and reduce duration of use and occupant comfort considerably.

CONCLUSION

The results of the study lead to the conclusion that straw bale building has a very high development potential, something which had already been indicated in studies carried out in the USA.

The fundamental technical basis and the necessary building certificates provided by this project prepare and facilitate the market introduction of this organic building material. In other words, an innovative building material is made available to the passive house sector. The study "Supporting and hindering factors for renewable resources in the building sector" (Wimmer, et al., 2001) points out that straw bale building can be used in many more fields than single family houses. This conclusion leads to further R&D questions which need to be worked on if the economic potential of straw bale building is to be fulfilled. R&D work to be done includes the following points:

- Improving the dissemination of straw bale building
- Expanding the variety of straw bale constructions regarding technique and design
- Improving the availability of straw bales in the desired quality and quantity
- Enabling the full regional potential of straw bale building to be fulfilled
- Maximising regional added value for local entrepreneurs and farmers
- Efficient co-operation structures for straw bale building
- Long term tests

The currently ongoing project "S-House" (www.s-house.at) a EU LIFE-Environment Project, will put into practice a straw bale demonstration project based on the results of this project. The "S-House" will help to disseminate all relevant information about ecologically sound constructions and building products made out of renewable raw materials.

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S - House : Innovative Use of Renewable Resources demonstrated by means of an Office and Exhibition Building

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1. INTRODUCTION

Both in the construction of new buildings and the redevelopment and restoration of old buildings, the building sector is the economic branch with the highest mass flows. At the moment, the materials used are mainly fossil and mineral based. In Austria the share of building waste amounts to more than 50% of the total waste. To reduce the building waste is one challenge for our society on the way to a sustainable development. Thereby renewable resources will play a major role.



Figure 1 Total amount of waste in Austria

At the moment the use of renewable rawmaterials is marginal, with only wood being used in significant amounts. But the potential for the use of renewable resources in the building sector is much higher. In nearly all areas one can find technical solutions based on renewable resources.

2. GOALS

The project goal is to plan, put into practice and demonstrate sustainable building by using renewable resources.

In defining sustainability for the building sector, the following conclusion is made:

The building concepts as well as the components and materials that are used have to meet the present needs of the user without burdening future generations with waste disposal problems or prolonged use of an out-dated building design.

In this holistic concept the construction of the building, the building itself and the use of it is put to serve the common goal of disseminating the potential of renewable resources throughout the building sector.

In particular this means:
The manifold applications of renewable resources within the building sector are demonstrated, based on the results of the study "Stimulating and Inhibiting Factors for the Use of Renewable Resources within the Building Sector", in which building products which were already available as well as new developments are listed.

Furthermore, this innovative building concept amalgamates and makes use of the results of the R&D projects within the scope of the programme "Building of Tomorrow". It also takes the results of the latest tests of building physical parameters into account, which were carried out within the study "Wall-System based on Renewable Resources - Verification of Technical and Building Physical Parameters of a Post and Beam Straw-Bale Construction and its Applicability for the Construction of Low-Energy-Houses".

3. INNOVATION

The innovative character of the planned building lies in its realisation of a "Passive House" integrating environmental and health criteria as well as using untreated renewable resources and an adapted building services concept. The user-friendly design of the building is of great importance, and allows for an efficient use of resources and energy from the planning stage of the building right up to its disposal.
The following technical solutions that are used show a high innovative potential:

- Significant reductions of mineral building materials through the use of renewable building materials.
- The special roof construction seperates the shelter from the heat insulation purpose, which results in additional functional and environmental advantages, like adaptable shadowing according to different seasons and resource saving rainwater collection.
- The modular biomass heating system is adaptable to rooms and chimenies of different size and is integrated into the housing services concept. It works as a radiant heater and increases occupant comfort considerably.
- Construction elements made out of TREEPLAST, a thermoplastically workable material consisting of wood chips (50%), crushed corn and natural resins. These newly developed components allow the construction of straw bale walls without any thermal leakage and are 100% biodegradable after use.

The use of the S-House can be regarded as having further innovative qualities in that the site and the building itself are an information platform for renewable resources and sustainable technologies.

4. ENERGY AND RESOURCE EFFICIENCY

The Life Cycle Assessment (Kohler and Klingele. 1995) of the used materials and the constructions shows the positive effects of straw bale building compared to conventional building methods.

Table 1 Two different wall constructions with a thermal transmittance (U-Value) of 0,12W/m²K are compared with the help of the Life cycle assessment methode (LCA)

Straw bale wall:	45 cm	Concrete-EPS wall:	49 cm
Clay plaster, inside	2	Lime plaster, inside	1
Wooden bracing	2	Concrete reinforced	15
Vapour barrier	0	Glue	0,2
Straw bales	35	EPS	32
Wind barrier	0	Glue, reinforcement	0,2
Wooden bracing	2	Organic plaster, outside	0,6
Lathing	2		
Exterior wood wall cladding, outside	2		

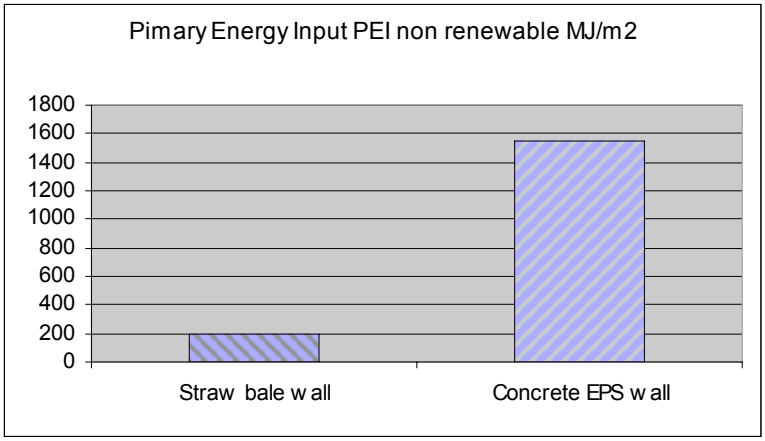

Figure 2 Primary energy input of non renewable energy in MJ/m², LCA calculation

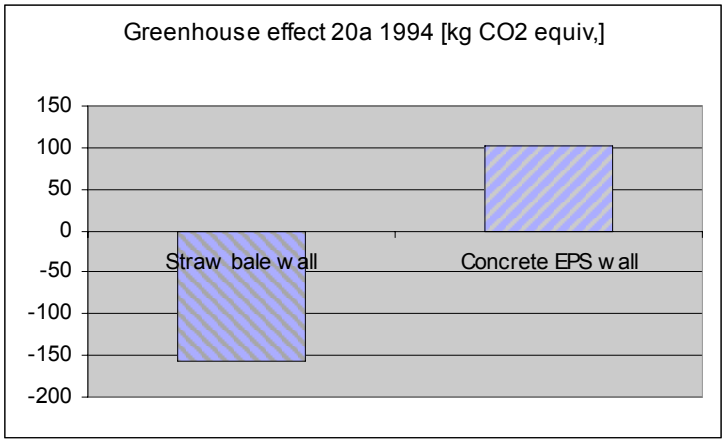

Figure 3 Greenhouse effect, LCA calculation

According to the criteria of sustainable development, the advantages of the innovative building concept lie in its use of regionally available resources. The compliance to environmental criteria and the co-operation between agriculture and economy contributes to the establishing of regional improvement.

Efficient use of energy and resources plays also an important role during the periode of use of the S-House. As it will be a passive solar house the energy consumption for the building is massively reduced and amounts to only one seventh of a conventional building. Furthermore any additional energy needed will be supplied with renewable resources for example solar energy or wood which is used for the biomass heating system.
The following figure illustrates the energy saving potential of different buildings.



Figure 4: Energy consumption of different building typs; 1 shows the amount of grey energy in MJ/m² and 2 shows how much energy (kW/m²a) for the heating is used.

5. LONG TERM FUNCTIONALITY OF RENEWABLE BUILDING MATERIALS

The permanent use of the building allows a realistic scenario for long term tests. The results are regularly updated and evaluated.
The long term tests aim to:

- Document of the most important building parameters, to show the functionality of the components and test the long term behaviour of the building materials.
- Verify the laboratory tests.
- Constantly monitor the building physical behaviour of the building and the components

The received data will be of great importance for the calculation and simulation of the performance of building materials made of renewable raw materials and the creation of new

norms. Furthermore, the devices for measuring and the continuous recording of the data will be one part of the dissemination concept and will enhance the experience of the visitor to the S-House and make the functionality of the innovative wall-systems and building services clearer.

6. DEMONSTRATING AND DISSEMINATING SUSTAINABLE BUILDING

The results of the whole process of planning, constructing and using of the building will be available to the public and will be integrated into the dissemination concept. Further aspects of the dissemination programme are excursions, multimedia presentation, internet presentation on the S-House homepage www.s-house.at, exhibition, public relation activities, presentation of the S-House at universities and at schools and at international and national congresses.

7. EXHIBITION

On the ground floor of the S-House a permanent exhibition will be installed, where the way of renewable resources from the field to the product will be shown. Furthermore, traditional knowledge as well as new developments and applications for renewable raw materials will be represented to the visitors.

8. FINANCE

The S-House is a EU LIFE Environment project. It is supported by the EU, the Austrian Federal Ministry of Traffic, Innovation and Technology and the regional government of Lower Austria.

9. TIME TABLE

Planing stage 2001-2002
Building of the S-House 2002-2003
Utilisation of the demonstration building 2004-



Figure 5 S-House draft - south elevation

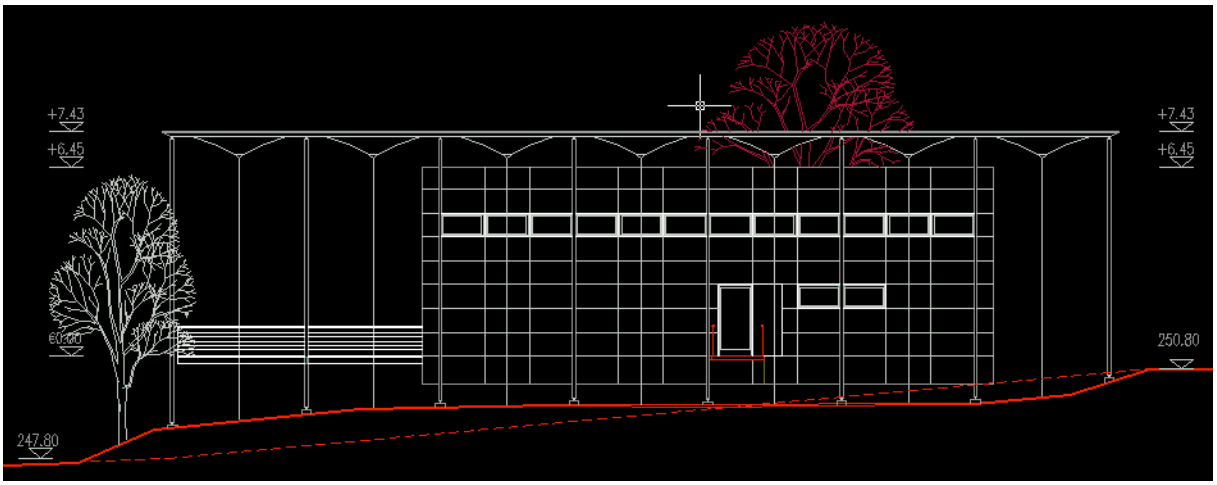

Figure 6 S-House draft – north elevation

10. CONCLUSION

With the S-House project environmentally friendly building methods will be demonstrated and a target group specific dissemination programme will supply a wide public with information which is essential for the successful spreading of sustainable building.

Data of long-term tests will be available, which will supply accurate reference data for calculations and simulations and norms for building materials made of renewable resources.

The modern architecture of the S-House will set an example for an environmentally friendly and ecological architecture freed itself from organic shapes and capable of meeting the criteria of a wide range of todays building applications.

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Development of a Demand-Side Management Program to Assist New Building Design Teams to Improve the Energy Efficiency and Sustainability of Their Projects

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1. BACKGROUND

Enbridge Consumers Gas (Enbridge) is a fully regulated natural gas utility responsible for much of southern Ontario including Toronto and Ottawa, operating in an area with a population of approximately 5,000,000 people. Enbridge serves 1,370,000 residential customers, 125,000 commercial customers, and 10,000 industrial customers. Total annual throughput is almost 12,000 million cubic meters. Figure 1 shows this territory.

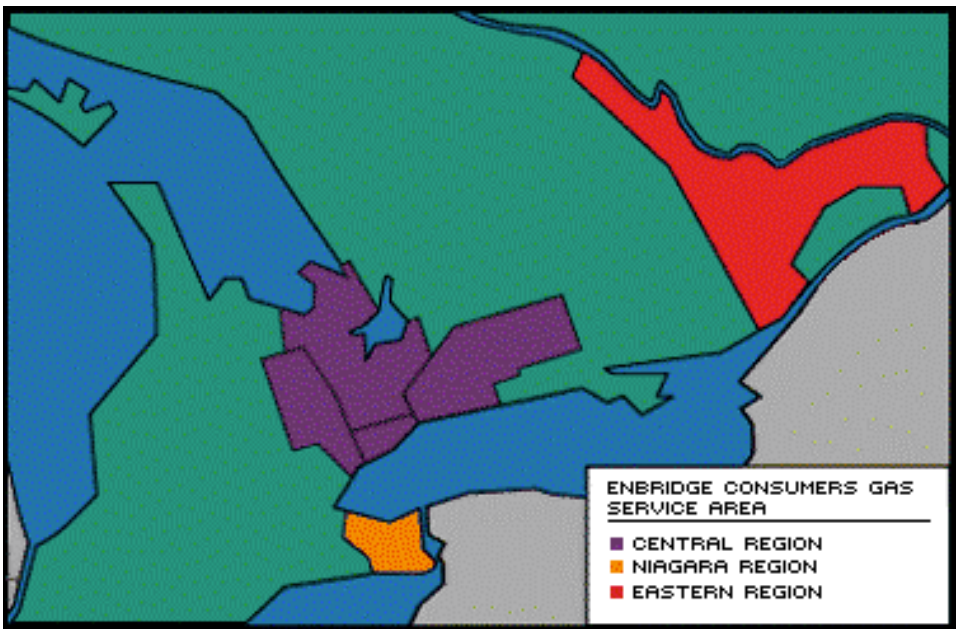

Figure 1 Enbridge service territory

The sale of natural gas has been deregulated in Ontario since 1987, but the transmission and delivery are fully regulated. Enbridge Consumers Gas is granted the right, generally on a non-exclusive basis, to deliver natural gas in the areas served, and has its rates, rate of return on debt and equity capital regulated by the Ontario Energy Board (OEB).

1.1 Enbridge Demand-Side Management Programs

Enbridge conducts its Demand-Side Management (DSM) activities within the regulatory environment wherein both the OEB and stakeholders (via a Consultative Group) oversee its planning, delivery and evaluation efforts. Enbridge is required to file annual DSM plans and evaluations for review and approval by the Consultative Group and the OEB as part of the annual rate case filings. A Shared Savings Mechanism (SSM) allows for an award/penalty to be paid to the utility shareholders if the utility exceeds or fails to meet its DSM volumetric savings commitment.

Enbridge Consumers Gas initiated its DSM efforts in 1995. DSM plans, programs and evaluation studies have evolved since that time with Enbridge successfully delivering programs across a spectrum of markets, delivered by the utility on behalf of all ratepayers and accessible to all customers. All programs are expected to be cost effective (from a societal and participant's perspective) with the acknowledgement that large industrial and commercial programs are likely to be more cost effective than residential programs. Enbridge has found that there are other advantages to DSM, including:

- Improved customer service
- Marketing Leverage promoting energy efficiency
- Energy efficiency and environmental issues are a positive contributor to the company's reputation

The Total Resource Cost Test (TRC), which is a net present value calculation that expresses discounted streams of costs and benefits as a single current year value, is used as the primary cost effectiveness screening mechanism for the SSM calculation. . It uses long-term projections of avoided costs for natural gas, electricity, water and other fuels to determine the benefits of a DSM initiative, but does not incorporate values associated with emissions reductions. Costs are those incurred by the participant and the utility in acquiring and delivering the more efficient technology. When benefits stemming from the projections of avoided costs are greater than the cost of the DSM installation, the program is cost effective. Under the SSM, the TRC net benefits of all the company's DSM programs (natural gas savings only) are summed and the Company receives 35% of the incremental benefits over the target as a shareholder reward.

1.2 Energy Efficiency in New Building Design

The design of new buildings is prescribed by the Ontario Building Code (OBC). Since 1993, all new buildings, other than low-rise residential buildings, have been required to be designed to be energy efficient as determined by the Canadian Model National Energy Code for Buildings (MNECB), 1995. This code is based on ASHRAE/IES 90.1-1989, and includes optional prescriptive or performance paths for compliance.

2. DEVELOPMENT OF THE DESIGN ADVISORY PROGRAM (DAP)

The Design Advisory Program is a DSM program directed at the Commercial/Institutional New Construction Market. The program has been designed to encourage design teams to participate in an Integrated Design Process (IDP) and to design a building that is significantly better than current new building design energy performance requirements cited in the Ontario Building Code (OBC). The DAP Program to date has 60 projects completed or in the pipeline since its inception in 2000, which represent 4,671,519 cubic meters of natural gas saved.

2.1 Program Goals

The following goals were established by the consultant, Engineering Interface Ltd. (EIL), and Enbridge:

1. Assist design teams in adopting new design approaches to all aspects of the building which impact on energy use, including the building envelope, lighting systems, mechanical equipment and systems, and controls.
2. Foster an improved understanding of mandated OBC energy code compliance and design options.
3. Assist in overcoming inherent barriers to energy efficient design, including:
   - high information and search costs for alternative designs and newer technologies,
   - default to design rules of thumb,
   - performance uncertainties about newer technologies,
   - organization practices for building design and operation,
   - product or service unavailability,
   - asymmetric information about technology choices,
   - inseparability of product features for energy efficiency and other attributes,
   - procurement practices and first cost emphasis on the part of owners.
4. Introduce new design tools to facilitate the energy impacts of different design concepts and technologies, including:
   - integrated design process to incorporate energy efficiency as a goal,
   - energy performance simulation,
   - envelope energy efficiency tradeoff,
   - product information and selection,
   - costing analysis.
5. Encourage owners and design teams to significantly exceed the minimum code requirements for energy efficiency.

2.2 Program Design Methodology

EIL undertook the development of a New Building Design Advisory Program through the following Tasks:

- Undertake a needs assessment
- Design a pilot
- Deliver design advisory services to three projects
- Evaluate the results and finalize the design

2.2 Needs Assessment

From surveys of architects and engineers involved in new building design, as well as regulatory building officials, the key findings were:

1. Most architects have the energy code compliance undertaken at the working drawing stage where significant changes are difficult and expensive to make, and they expect only the mechanical engineer to undertake this compliance process.
2. Most clients request that building designs simply meet the basic performance levels mandated by code and have little interest in efficiency improvements if project first-costs will likely increase, especially for developer type projects.
3. Various occupancy types require energy efficiency measures appropriate to the building type, and special knowledge of such strategies is a significant part of the design service.
4. The performance path of the energy code is rarely used.
5. Most respondents stated their preference for the Design Advisory service at the Schematic Design Stage or earlier.

6. Architects want to receive a variety of services, including:
   - modelling of energy usage and energy cost savings for design options,
   - capital cost estimates resulting from design options,
   - design improvements without major demands on in-house staff or budgets,
   - training,
   - new rules of thumb for design,
   - guideline details and manuals,
   - mechanical/electrical performance specification for design/build projects.

2.3 Pilot Program Design

From the Needs Assessment phase, key requirements for the program were defined:.

1. The Design Advisory service should enter into the design process at or before the Schematic Design step where the architect provides design sketches to the owner, thereby having the opportunity to work with the complete design team from the point of its formation.
2. The service should be offered to the owner rather than the design team, with a view to setting up a basis for charging for the service in the full scale program.
3. The development of an energy performance model using the MNECB performance path will be a useful step for introducing the performance path to design teams. This will allow the design facilitator to move from facilitation to assisting the design team to comply with the requirements of the Ontario Building Code for energy efficiency, as a value-added service to the design team.
4. The development of energy cost savings, capital cost estimates, and resulting simple paybacks will be viewed as useful by architects and engineers if they become comfortable with the service, to assist in the presentation of design options to the owner. The design team, however, will be much better and more current at developing cost estimates that the Design Advisory Team.
5. It will be necessary to consider a charge for the service in the full program. This could have some relationship to the energy cost savings since these will be defined with reasonable accuracy during the process. Linking the charge to capital cost reduction would be more palatable to the owner of a leased building, where the tenants will pay the operating expenses. Since designers usually operate on a fee which is a per cent of the capital cost, they are unlikely to be interested in paying for such a service. The potential access to a CBIP incentive might compensate for this problem.
6. The assistance of the gas utility sales personnel in opening the doors to the project owner and design team will be very necessary to sell the service. A direct approach by the design service team would be viewed as an intrusion by the mechanical engineer in particular, and a reflection on the value of their services.

A review of other similar programs offered in other jurisdiction confirmed these goals as appropriate for DAP.

2.4 Pilot Phase

The pilot phase included an automobile dealership, a primary school and a multi-unit high-rise residential building. In each case, an energy performance model was developed to evaluate potential energy cost savings, and a range of measures were offered to the owner and design team. The design advisory team had to move quickly to match the pace of the design team, a reality due to the arrival later in the design process than had been requested. The

owners' representatives expressed considerable satisfaction with the outcome of the Design Advisory program, and design teams.

2.4 Conclusions and Recommendations

1. The Design Advisory Program was well received by program participants, and has the potential to improve the energy efficiency of new building designs in Ontario.
2. The Design Advisory Program must find projects early in their development, preferably at the Schematic Design stage, but definitely before the production of working drawings and specifications.
3. The design advisory process is one that must recognize certain realities, namely:
   - Design teams are intensely proud of their creation. It is their building.
   - Design teams sell their overall competence to the building owner/developer. Energy efficiency is one of those competencies, and there are many others.
   - Design advisors are usually there at the request of the owner. Thus they are imposed on the design team.
   - The design team is ultimately responsible for the health, safety and functionality of the building. Energy efficiency is a much lower priority.

   For these reasons, the process must be a supportive facilitation. The approach offering the highest probability of success is to offer advice and assistance to the design team while recognizing their ownership of the project. Cooperation and collaboration are the keys. The design facilitator must always be seen to in a position of offering advice, suggesting energy efficiency improvements, and recommending a process. It is possible that some training will be required to ensure these principals are adhered to by all advisors.
4. Enbridge should seek to have input from those design advisors who have experience with the program, to ensure their experience is captured in the final program design. This could include developing a consistent information presentation, and also a review of costs for the service. This could be done in a one-half day workshop.
5. One useful item would be a simplified screening tool during the preliminary meeting to develop potential energy cost savings for some measures, to avoid the need for developing a full energy model before any results can be provided.
6. While the project team did not adequately test the concept of a charge for the program, it is clearly more palatable if the project receives other incentives.

3. FINAL PROGRAM DESIGN

After operating the program for one year, a meeting with the Design Advisers was held, and the following conclusions reached:

1. The program is being successfully delivered, but there are differing views on the definition of an Integrated Design Process.
2. The use of a screening tool would assist in positioning the cost/benefit potential measures for further consideration, particularly at the early stage of the design process.
3. A process for selecting and training Design Advisers will need to be developed to permit the program to expand to all Enbridge service areas.
4. In the near term, the program will continue to be offered at no cost to owners.

In a subsequent task, a two day meeting with experienced design facilitators from across Canada was convened to address the issue of defining the Integrated Design Process. From this meeting, the following definition was developed:

The Integrated Design Process (IDP) is a method for realizing high performance buildings that contribute to sustainable communities. It is a collaborative process that focuses on the design, construction, operation and occupancy of a building over its complete life-cycle. The IDP is designed to allow the client and other stakeholders to develop and realize clearly defined and challenging functional, environmental and economic goals and objectives. The IDP requires a multi-disciplinary design team that includes or acquires the skills required to address all design issues flowing from the objectives. The IDP proceeds from whole building system strategies, working through increasing levels of specificity, to realize more optimally integrated solutions.

"Quality Programme Bo01" in the Building Process: Two Case Studies of Actors' Approaches to Environmental Requirements

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1. INTRODUCTION

The building industry is often depicted as conservative and slow to change. According to Kadefors (1995) the building industry is subject to strong institutionalisation, which means that flexibility is constrained by the buildings themselves, the work processes and the occupational roles. Still, there are efforts made to defy conservatism and introduce change – such as sustainable building – for example through demonstration projects. Demonstration projects serve several purposes: as a source of inspiration and information about building design for building industry and other interested parties, but also as an opportunity for the actors involved to learn more about sustainable building during the realisation of the building process (Femenías, 2000). One recent example of a demonstration project with sustainable development as its theme is The European Housing Expo *Bo01 City of Tomorrow* that took place in Malmö, Sweden, in 2001. As a means to bring the ideas of sustainability into the building process, and hence the built environment, an environmental programme, *Quality Programme Bo01* (Dalman, 1999), was developed.

Even if there are previous examples of projects where environmental programmes have been used (Pettersson 2001), environmental programmes as a phenomenon are still rather new to the Swedish building industry. Quality Programme Bo01 can thus be considered to represent a novel feature in the building process. The requirements in Quality Programme Bo01 have impacts on all levels of the building process. One aspect yet to be studied is how organisational position and occupation affect how an actor in the building process understands a document like Quality Programme Bo01. The aim of this paper is to show how different groups of actors in the building processes of two building projects at Bo01 interpreted and worked with the Quality Programme Bo01. This study is part of a larger research project aiming at evaluating Quality Programme Bo01.

2. METHOD

The first phase of this study consisted in gaining knowledge about Quality Programme Bo01. In order to gain background information about the Expo and the ideas behind the Quality Programme, open-ended interviews were carried out with three persons in the Bo01 organisation: the Exhibition Architect, the Project Leader who wrote the programme, and the Environmental Manager. Question themes were: background and organisation of the Expo, the Quality Programme and its development, applications and follow-up. The interviews took place at Bo01's office in Malmö in December 2001. Each interview lasted for about one hour and was recorded and transcribed.

There were 17 building projects at *Bo01* – two of the larger projects were selected as subjects for a case study. These projects represented different types of developers and different contracting forms. One developer is a large construction company whose project was organised as a design-construct contract and the other is a local, medium-sized real-estate firm whose project was organised as a general contract. Open-ended interviews were made developers, designers and contractors in the two projects. Interviewees in the large contracting company were the developer's Project Manager, the Design Co-ordinator, one Installation Designer, the Project Engineer, and one Supervisor who also co-ordinated the environmental work. Interviewees in the medium-sized real-estate firm were the developer's Project Manager and Environmental Manager, the Environment Consultant, the Energy Consultant and the contractor's Site Manager. The interview questions were structured into themes: background information about the company, interviewee and project, the Quality Programme and how it was handled and experienced in the design phase and the production phase. The interviews were carried out between September 2000 and April 2001, i.e. during a period when the design was almost completed and the production was in its busiest phase. Each interview lasted 1-2 hours. All interviews except one were made over the phone, and all interviews except one were recorded and transcribed.

3. QUALITY PROGRAMME BO01: AIMS AND CONTENTS

The ecologically sustainable information welfare society was the theme of the Bo01 City of Tomorrow European Housing Expo. As a means to secure that sustainability would become inherent in all aspects of the Expo, a Quality Programme was developed as a co-venture of the Bo01-organisation, the City of Malmö and some prospective developers. People from Bo01 suggested requirement levels and negotiations were carried out with the developers until all parties could agree on the formulations. The reason for bringing the developers into the creation of the programme, was that then they would be committed to the programme when they bought land on the Bo01-area from the city.

The targets of the Quality Programme were to give the developers a common basic standard, to be an operative instrument during the planning and construction of the new district, and to ensure high quality in environmental profile, technology and services as well as in architectural planning and design. The first part of the programme describes the sustainability visions behind the Expo, and the second part contains quality descriptions and requirement levels. There are more than 100 requirements, and for each one, a party responsible for the fulfilment is pointed out: the City, Bo01 or the developers. One goal was that each actor participating at Bo01 would be familiar with the programme. The Quality Programme was included in the development and Expo agreements that the developers had to endorse.

4. CASE STUDY: QUALITY PROGRAMME BO01 IN THE BUILDING PROCESS

The case descriptions show how the programme was used in two projects, and are organised to reflect three groups of actors: the developers, the designers and the contractors.

4.1 The Large Construction Company

This project was the result of an architecture competition arranged by *Svenska Boprojekt*[1] together with NUTEK[2], where the task was to design a multi-storey wooden house. The reason for using wood in this project was not primarily that wood often is argued to be an "environmentally friendly" material, but rather to market the Swedish forest industry's

[1] The organisation that initiated Bo01.

[2] A Swedish authority working for the development of Swedish industry.

products. As a consequence there were many new wood-related design and technical solutions in this house. The developer organised the project as a design-construct contract, where all actors except the architects belonged to groups within the company. The company was certified according to ISO14001 in 2000, and has its own company-wide environmental tools to be applied in all building projects.

4.1.1 The Developer: With Concern for Economy and Customers

The developing company wants to be recognised as a "safe alternative", that assures its customers of functional and financial reliability. The developer's Project Manager emphasised that this applied also to the Bo01-project, even though the project, as a consequence of the Expo, was more exclusive than ordinary residential property. The Project Manager took part in the negotiations about Quality Programme Bo01, defending the developer's interest of "realistic" – that is financially practicable – requirements. Therefore disagreements occurred when Bo01 at times wanted to view the whole Expo as a gigantic research project. In the end the Project Manager was pleased with the resulting programme and thought that it would contribute to a green and lively housing area with a guaranteed high "lowest quality level". The Quality Programme was part of the development agreement with the City and therefore the requirements were to be followed even though some requirements were weakly formulated and therefore became subject to interpretation. The developer did not "remove" any of the requirements in the programme, but added requirements on the indoor environment, which is something that customers ask for. All in all, the project involved a number of clever, but not really the newest, technical solutions – that did not cost too much.

4.1.2 The Designers: Dealing With Requirements: Material and Technical Solutions

Special about this project, from a designer's point of view, was the ambition to develop wood as a building material – and in that respect this was a developmental project. The documents that directed the design process were Quality Programme Bo01 and the company's environmental management tools, including for example databases on building materials and chemical substances and lists on forbidden materials. Each designer was responsible for environment and quality in his or her work – and also for reading the Quality Programme and single out the relevant requirements. Most parts of the Quality Programme were not directly applicable to the designers; when reading the programme, they focused on the requirements and skipped visionary descriptions. About one third of the requirements affected the design process. When needed, the content of the Quality Programme was discussed at the design meetings. The Design Co-ordinator recognised and understood most of the requirements - the novelty was that the programme comprised so many different areas. Both the Design Co-ordinator and the Installation Designer thought that the amount of text made the programme difficult to grasp, and would have preferred the requirements grouped according to which actor they affected. The Design Co-ordinator stressed that, since environmental issues still is new to the building industry, requirements like these should be concrete and well motivated in order to give guidance to the actors. Neither the Design Co-ordinator nor the Installation Designer thought that the requirement levels were too different from other housing projects.

4.1.3 The Contractors: Work Environment and Quality of Work: Time Pressure

The interviewed contractors - the Project Engineer and the Supervisor – considered the Quality Programme as something that mainly affected the design phase and therefore assumed that the requirements were included in drawings and technical descriptions. The company's environmental and quality systems were conformed with, also in the production phase. The Supervisor was knowledgeable with the programme and was assigned to the task of following up the designer's fulfilment of the requirements. The Project Engineer – who was responsible

for procurement of subcontractors and building material – did not know the programme very well. When time pressure was hard, the amount of text had a deterrent effect – resulting in the programme remaining almost unread on its shelf. The Project Engineer thought it would have been better to concentrate on a few requirements and include them in the contract. Following the company's environmental system, the contracts with subcontractors and material suppliers included the company's environmental requirements on materials and logistics. Quality Programme Bo01 was not included in these contracts. The choice of subcontractors was based on price and work skills, while their environmental work had low priority.

Regular meetings were held with subcontractors and developer - environment did not have its own slot on the agendas of these meetings, however quality did and some of the "quality discussions" had to do with environment as well. According to the Project Engineer, environmental concern at a building site not only has to do with using the right materials, but with quality of work and work environment for the workers. In this project, the work environment was affected negatively by the hard time pressure and the overcrowded Bo01-area.

4.2 The Medium-Sized Real-Estate Firm

4.2.1 The Developer: Trying Something New

This developer is a medium-sized real-estate firm that considers itself a market leader in the Malmö area. The developer's Project Manager viewed the participation at Bo01 as a chance to show the firm's prominence, as well as an opportunity to try out – and receive feedback on – new solutions for future housing. In the project, a number of new technical solutions were combined, and the developer's Environmental Manager was planning information activities to change the residents' environmental behaviour. When discussing Quality Programme Bo01, the Project Manager thought that the requirements in worst case could become a "good-enough level" instead of a "lowest level". However, the Project Manager thought that the aim of participating at Bo01 hardly was to get away with doing as little as possible – especially since building projects at exhibitions like Bo01 hardly are good business in themselves.

4.2.2 The Designers: The Importance of Knowledge: Reformulating the Requirements

All designers, except the architect, belonged to one consultant firm that the developer had previous experiences of working with. Both interviewed consultants - the Environment Consultant and the Energy Consultant – had the impression that the developer wanted something better than the ordinary. According to the Environment Consultant, the resulting building contained materials that were more environmentally adjusted than what is usual. In this project, the requirements of Quality Programme Bo01 were transformed into a project-specific Environmental Programme (Harrysson and Adalberth, 2000) that was valid for both design and production. The programme is based on Quality Programme Bo01, the Real-Estate Firm's environmental policy and Miljömanualen[3] (Miljöstiftelsen för byggsektorn) and contains all requirements in the Quality Programme, but also additional requirements, for example on the indoor environment. The Environmental Consultant stressed that when deciding on relevant requirement levels it is of utmost importance to have knowledge of where to find information. Both interviewed consultants explained how they had compared the Quality Programme to their own experiences, existent standards and findings in research reports and doctoral theses in order to decide on the requirement levels in the Environment Programme. The Environment Consultant emphasised that this kind of requirements must be concretised and that the impact on each actor must be explicitly addressed. Consequently, the Environmental

[3] A tool for environmental decision-making in all parts of the building process.

Programme was formulated to declare the responsible party and motivated the level of each requirement with a background description and sometimes with references to Miljömanualen.

4.2.3 The Contractor: The Importance of "Smart Building" and Work Environment

When the developer choose a general contractor, price was the selection criteria – however all tenders were well-reputed contractors who had their own quality or environmental systems. The Environmental Programme was included in the contract between the developer and the general contractor. The contracting company is a large construction company with an ISO 14001-certificate and thus has its own environmental management system with internal environmental requirements to follow in all projects. In this project, the Site Manager compiled the different requirements into a production-specific programme that was used in the production phase. Regarding the Environmental Programme, the Site Manager felt respect for it, since it showed that it was written by someone with knowledge of construction. As a contrast, the Site Manager found Quality Programme Bo01 fuzzy and difficult to apply to a building project – and thought that the persons responsible probably knew a lot about environment, but not about building sites.

The Site Manager thought that the environmental concern in the building projects at Bo01 generally suffered due to time pressure; that it is impossible to carry out a huge project like Bo01 in 12 months and at the same time take the environment into consideration. If environmental issues are to be considered in production, it is important to "build smart", which in this project was obstructed by incomplete detail solutions on the architect's drawings. The Site Manager viewed the work environment as the most important environmental issue on a building site. Positive about this project was that the co-operation between contractor, developer, and subcontractors worked well. When workers on several other building sites at Bo01 went on strike, the workers at this project stayed at work – a strike would otherwise have increased the time pressure.

5. DISCUSSION AND CONCLUSION

The case studies describe two projects where the developers have had different strategies in, and motives for their participation at Bo01. While the medium-sized real-estate firm wanted to try new ideas, it was important to the large construction company that the project was commercially practicable. Also, the sustainability requirements in Quality Programme Bo01 were handled in different ways in the two projects. In the large construction company, Quality Programme Bo01 existed parallel to the company's own environmental system. The requirements in the Quality Programme primarily came to be used in the design phase where they were incorporated in drawings and descriptions. The drawings and descriptions naturally affected the production phase – where the Quality Programme was, not altogether unknown but at least very remote. However, the company's own environmental management system was in active use, providing environmental management also in the production phase. In the medium-sized real-estate firm, the Quality Programme and other requirements were merged into a project-specific Environmental Programme, which was formulated so that it "survived" – that is, was used – throughout building process. This study does not enable the determination whether one process resulted in more sustainable building than the other, since the actual product – the house – was not evaluated.

There were similarities between groups of actors in the two projects – similarities that probably are due to actor roles and work content. In both projects, it was the designers that worked most actively with the Quality Programme – and who had nuanced opinions about its content. This is natural, since many important decisions – such as choice of systems and

materials – are made in the design phase. The contractors in both projects, emphasised the importance of work environment – because healthy and content workers take more care in their work tasks – and quality of work. This was not at all reflected in Quality Programme Bo01. It may be so that a good level on the quality of work is taken for granted – this is simply what the contractors are paid to do. The contractors in both projects mentioned that the time pressure was hard – which may have obstructed the quality of work.

All interviewees were aware of the existence of a Quality Programme, but even if the requirements were worked into the projects and the buildings, the visions remained largely unknown, or at least were not paid much attention to. The actors looked for the hands-on requirements, and the visionary parts with their embroidered text did obviously not appeal to them. Further, the actors spoke in terms of environment and quality rather than of sustainability. One explanation to this is that the requirements that affected the designers and contractors were ecological and technical. Another explanation is that the concepts of environment and quality have been known to the building industry for some time; clients often request quality and environmental management systems and an growing number of companies gain ISO-certificates. Thus, the issue of environment has entered the building industry and is becoming increasingly known to the actors; this may be an example of an ongoing institutional change.

This study has shown that it is important to consider that different groups of actors in the building process contribute to sustainable building in different ways. It is a long way between a vision of sustainability and a sustainable building – not to say a sustainable society. It is laudable to gather great ideas and present them in written text, but in the building industry this is not enough. How a document such as Quality Programme Bo01 is presented have impact on how its message is received. Therefore it is important to increase the understanding of what sustainability means in different parts of the building process, and to gain insight of how requirements can be formulated to commit – and enable – every actor to consciously contribute to sustainable building.

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Material and energy flows in different types of urban structure

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1. INTRODUCTION

Until the present economic and market considerations have driven housing stock development. However, environmentally acceptable development requires assessments of the energy and material requirements characteristic of the different building and urban structure types. IOER's research was intended to derive energy and material parameters that could provide a basis for projective material flow management. To achieve this, a model to analyse and estimate the quantities of materials required for the different kinds of urban structure types and their associated energy and emission parameters was developed. Using this model, the material and energy parameters for the different kinds of urban structure could then be calculated. The following types of urban structure were examined: enclosed blocks, partially enclosed blocks, completely developed blocks, partially developed blocks, linear development, detached single family housing, larger detached houses, large urbanizations with prefabricated housing and housing estates.

2. MODEL USED FOR ANALYSING AND ESTIMATING THE MATERIAL AND ENERGETIC PARAMETERS OF DIFFERENT TYPES OF URBAN STRUTURES

The model is made up of two basic components; component I, which functions at the level of individual buildings, and component II, which functions at the level of land use for residential building. Extrapolations are made using these two components and the building mix. (Fig. 1).

Component I contains the main material calculation programme for buildings. It allows the calculation of the amounts of materials used in buildings seen either as material depots or as material intensities, thus allowing the calculation of the relevant energy and emission parameters. The amounts of building material – and their energy and emission parameters - can be split up, allowing a differentiation not only for different building elements (such as walls, floors, roofs etc.), but also for particular kinds of material (such as brick, concrete, wood, metals etc.)

The material and energetic parameters for different types of building can be transformed by extrapolation at the development type level. The basis for the extrapolation is the **building mix,** which specifies the proportions of different kinds of building in a particular type of urban structure.

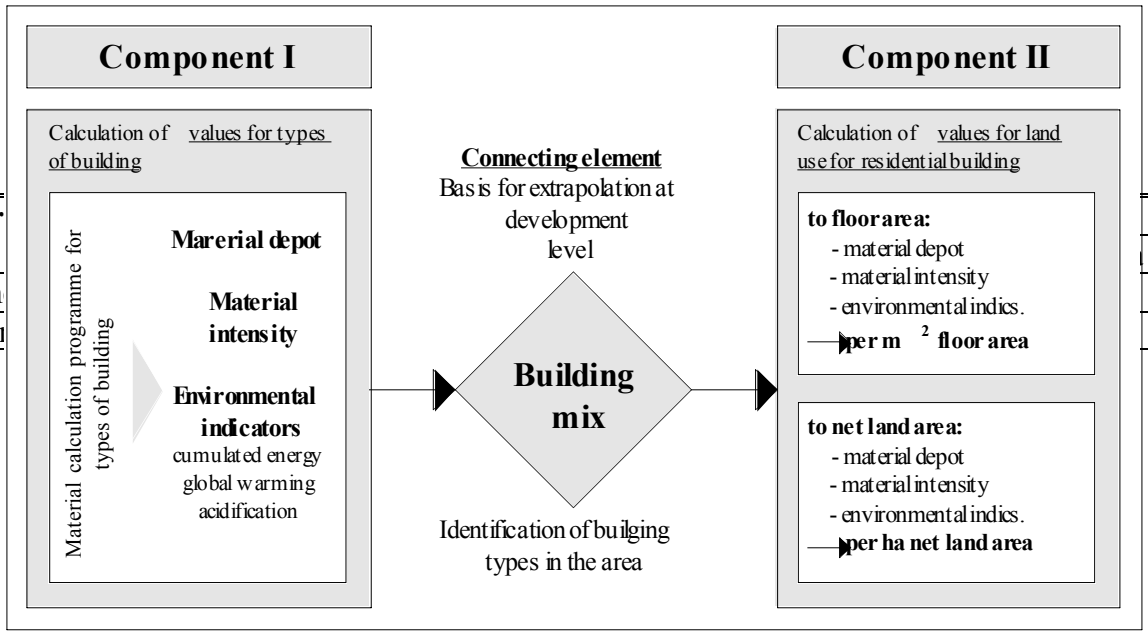

Figure 1: Model for analysis and estimates (Source: IOER)

Component II contains the extrapolations for arriving at the material and energy parameters at the urban structure type level. These can be expressed either in relation to the living area in the area under examination or in relation to the net area of land used for residential building.

3. MATERIAL AND ENERGY PARAMETERS OF DIFFERENT TYPES OF URBAN STRUCTURE

Urban structure type analyses were carried out in two medium-sized cities (Freiberg and Zittau) and one large city (Leipzig) on the basis of the urban structure type mentioned above. **Material intensity** will be dealt with below as a dimension which is calculated on the basis of the **buildings** in the area being analysed and its associated **infrastructure.** So far as buildings are concerned, two material intensities are important. They are the material intensity in metric tons per square metre of floor area (t/A_{fl} m^2) and in metric tons per hectare net area of land used for residential building (t/net B_{res} ha). So far as infrastructure is concerned the figures are all in metric tons per hectare net area of land used for residential building (t/net B_{res} ha).

3.1 Material intensity in different types of urban structure - buildings

The material intensity in metric tons per square metre of floor area is dependent on the building mix, and thus in the buildings standing in the urban area under analysis. The material intensity in metric tons per hectare net area of land used for residential building is primarily dependent on the building intensity and the building mix, and must thus be seen as an urban planning parameter.

The results show that a meaningful differentiation from a material and energy point of view on the basis of urban structure type can indeed be made. The first approximate values for material densities can be derived from empirical analysis (Tab. 1).

The material intensities of the different types of urban area in medium-sized and large towns are similar. The material intensity in the large town of Leipzig is somewhat greater than in the medium-sized towns of Zittau and Freiberg, because these towns' buildings are smaller and not so high. (Fig. 2).

Single family housing development	3.7	5,500

Larger detached houses	2.5	
Linear development	2.1	12,500
Urbanizations with prefabricated housing, housing estates		20,000

Table 1: Material intensity of different urban areas (buildings) – first approximations (source: IOER)

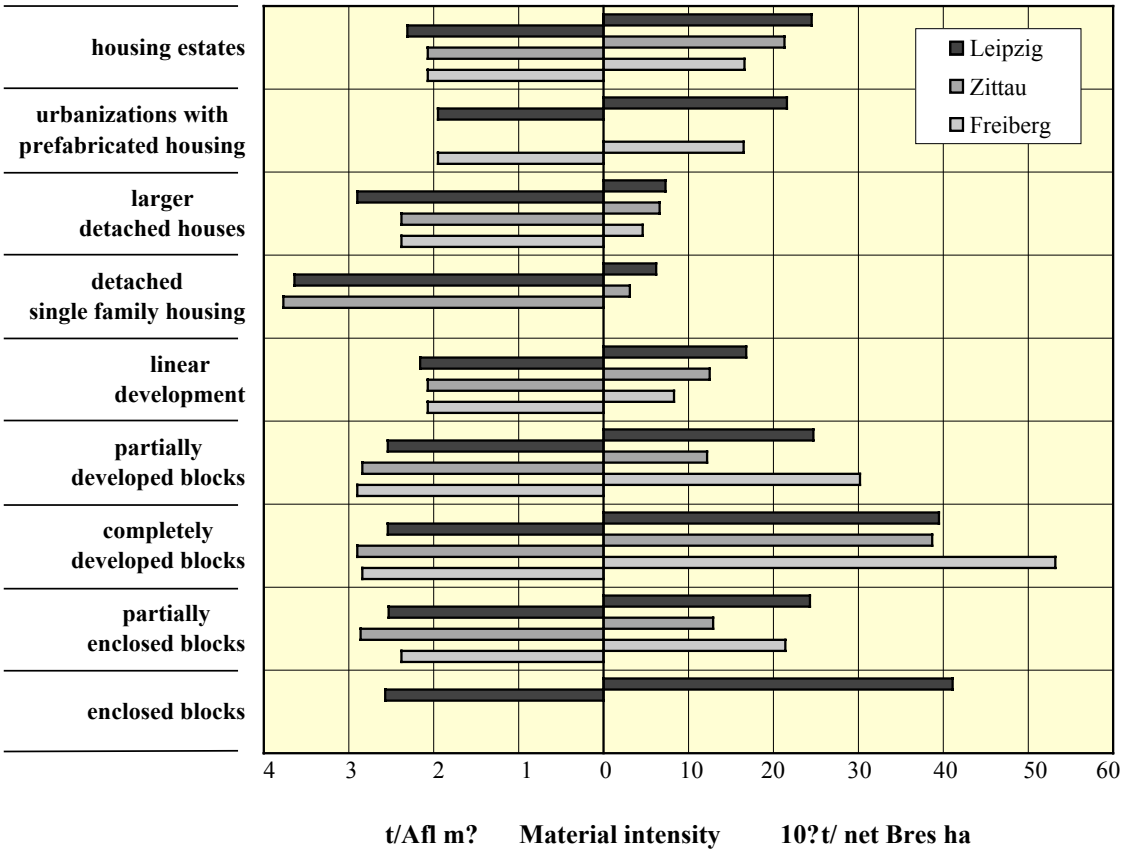

Figure 2: Comparison of material intensity of different types of urban structure (buildings) – Freiberg, Zittau und Leipzig (Source: IOER)

The **material intensity per square metre of floor area (t/A_{fl} m^2)** is similar in the enclosed blocks, the partially enclosed blocks, completely developed blocks and the partially developed blocks. In spite of the similarities, differences between urban structures of the medium-sized towns and the large town of Leipzig are noticeable. In the medium-sized towns, the urban structure is predominantly one of two or three-storied brick buildings, which are more material intensive - i.e. show a greater material intensity per square metre of floor area (t/A_{fl} m^2) - than the four-storied brick buildings which tend to be characteristic of Leipzig's type of block structure. In this connection, the influence of the number of floors of the pre-1870s developments and the early 1870s developments on the material intensity becomes quite apparent.

In the case of linear developments, large urbanizations with prefabricated housing and housing estates the material intensities per square metre of floor area are similar. Nevertheless, particularly the linear developments and the housing estates show minor differences between the medium-sized towns and the large town.

The areas of single-family housing have the greatest material intensity per square metre of floor area.

Of the types of block structure, the completely developed block type and the enclosed block types consistently show a greater **material intensity in metric tons per hectare net area of land used for residential building (t/net B_{res} ha)** than the partially developed, less densely built areas. On average the difference is some 20,000 metric tons per hectare net area of land used for residential building (t/net B_{res} ha). No characteristic differences are to be seen between the completely developed block type and enclosed block types of medium-sized towns and the large town.

The urban structure types with linear development, large urbanizations with prefabricated housing and housing estates consistently show less material intensity related to net area of building land than the block type of structures. The lowest material intensity values of, on average, 5,500 metric tons per per hectare net area of land used for residential building (t/net B_{res} ha) are to be found in areas of detached single family housing and areas with larger detached houses; this is due to the lower development density. These types of area show a clear difference between the medium-sized towns and the large town.

3.2 Material intensity of the different types of urban area: infrastructure

In much of the literature on material flows in relation to housing and building the infrastructure has not, until now, been dealt with adequately. Thus, as part of the technical structure analysis the different types of road, road surfacing, and services (water, waste water, gas, district heating) were analysed in cooperation with the Institute for Urban Development and Road Construction of Dresden Technical University, and their values calculated (Lipkow 2001). This showed that of infrastructure material 85 to 95% is accounted for by road surfaces, and 5 to 15% by services.

On examining the individual types of urban structure it became clear that the infrastructure material intensity did not differ as much as did that of the buildings. Nevertheless, significant infrastructure differences could be associated with the different types of urban structure. It must also be borne in mind that infrastructures are always net-like, which can lead to a lack of clarity. So that the differences between the different types of urban structure remain clear, corrections have to be applied.

3.3 Material intensity in different types of urban structure: buildings and infrastructure

On considering the material intensities of the buildings and the infrastructures it is noticeable that the material intensities of the different types of urban areas – which results from the type of buildings – differ clearly from one another, while the infrastructure material intensities differ far less. (Fig. 3).

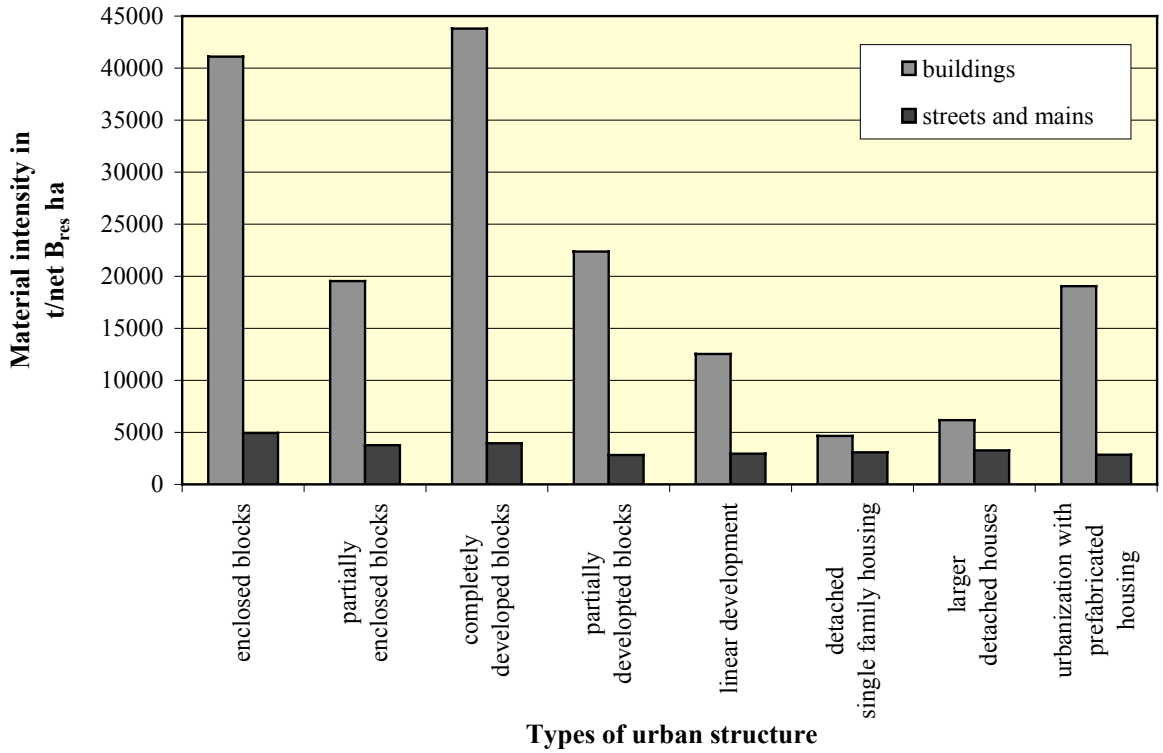

Figure 3: Material intensity of different urban structure types (buildings and infrastructure) – average values for Freiberg, Zittau und Leipzig (Source: IOER)

The proportion of infrastructure material intensity to building material intensity can vary between 10 and 70%. In areas with completely developed block structure the proportion is 10%. In contrast, areas of detached single family houses the infrastructure material density can be as much as three quarters of the amount of material used for the buildings. Until the present little attention has been paid to these proportions.

Putting the results of the survey in relation to the building/area ratio there is a clear correlation between building/area ratio and material intensity. Though this not surprising, it is informative, as it allows the derivation of values for comparison in urban development. A difference of 0.1 in the building/area ratio means a difference of some 1,900 metric tons per hectare net area used for residential building. Although a similarly exact value cannot be derived for infrastructure material intensity, the range for infrastructure material intensity is from 4,000 to 5,000 metric tons per hectare net building area for the building/area ratio 0.1 to 2.8. It is thus nearer to being a constant than showing a linear increase.

4. SUMMARY

A model for the analysis and calculation of material and energy parameters was developed as part of the surveys described above, which allow the calculation of the material depot, and the material intensity of the existing building stock with their corresponding energy and emission parameters both at the level of individual buildings and the area under consideration.

The material intensity of the urban area concerned is made up of the infrastructure material intensity and that of the buildings; i.e. the material intensity represented by the buildings standing in the area under consideration and the existing infrastructure (roads, services) determine the material intensity of an urban area. The influence of the infrastructure material intensity is, as a rule, of lesser importance.

Following the analysis of various types of urban area it becomes clear that the material intensity of the buildings for the same type of area was characteristic both in metric tons per square meter of floor area and per metric ton per net hectare of building land in medium-sized towns and a large town. This allows, for the first time, the derivation of values for comparison and extrapolations, allowing the estimation of material requirements without carrying out complicated analysis.

Buildings, particularly, show a nearly linear correlation between the building/area ratio and the material intensity in metric tons per net hectare building land. This fact can be utilised to estimate the material intensity of existing residential areas.

The material intensity represented by infrastructure did not vary as much as that of the buildings. Nevertheless, it was possible to assign significant infrastructure characteristics to the different types of urban area and to clarify the importance of infrastructure input in detached family housing areas. It must, however, be borne in mind that infrastructures have a network character, and that corrections have to be made to avoid the blurring of structure differences.

The parameters and comparative values arrived at in the course of the surveys make it possible to estimate and describe the amounts of material and energy embodied in the housing stock including technical infrastructure. They allow the estimation and evaluation of different modes of development and offer a basis for the consideration of material flows.

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No Sustainable Building without Sustainable Infrastructure

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1 INRTODUCTION

Ecological investigations of urban planning and site development concentrate in the main on buildings so far. Little attention has been paid to urban infrastructure, though it is a prerequisite for operative buildings. Until now there is almost no knowledge regarding the infrastructure induced mass flow of buildings, but in fact, the specific infrastructure material mass is not a negligible quantity within the building stock. In low density built up areas the material stock of infrastructure per m² floor space may add up another 70% of the specific building mass. The investigations goes on from here to infer urban planning guidelines for ecological aspects of buildings including local technical infrastructure.

2 URBAN STRUCTURAL UNITS

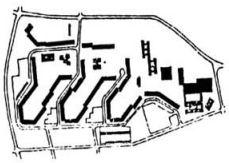
Empirical studies focused the building stock and the essential public infrastructure facilities of residential areas (public thoroughfare and mains), characterised through typical urban structure (urban structural units). Urban structural units are defined as "areas with physiognomical homogenous character of built up area marked by a characteristic formation of buildings and open spaces" (Wickop et al. 1998). In order to picture residential areas, they may be subdivided into urban structural units (Figure 1). The base of the presented investigations is a definition of urban structural units along *use* (predominantly habitation), *structure of development* (heavy built up blocks, lager detached houses (villas), linear development, large prefabricated housing estates and single family housing) and *building type* within the structure units (size, age, construction). Furthermore the urban structural units are characterised by specific urban density.



heavy built up blocks



linear development



prefab. housing estates



detached single family housing

Figure 1: Examples of different types of Urban Structural Units

The urban structure approach provides a frame for ecolgical investigations of buildings *and* the necessary public infrastructure facilities – streets, sidewalks and mains of public utility and disposal.

3 MATERIAL STOCK AND URBAN DENSITY – EMPIRICAL FINDINGS

In the frame of the research project "Approaches to a Sustainability-oriented Development of the Housing Stock in Saxony," building- and infrastructur faclility- equipment of urban structural units was empirically investigated (Deilmann et al. 2001). Characteristics of buildings[1] where registrated within selected blocks in the case-study-cities[2]. A GIS-based analysis of lengths and widths of public streets and their construction characteristics was realised within lager residential areas. Mains quantities were analysed on base of informations given by utility companies. Based on the empirical material the material stock of buildings and inrastructure facilities was calculated.

The results of the research have shown a clear relation between the specific infrastructure induced material mass per floor space of buildings and urban density (Figure 2). The former is decreasing with growing floor space index. In heavy built up blocks the material mass of infrastructure facilities is larger in quantity than it is in low density areas, but related to floor space, in high density areas the specific infrastructure material mass is clearly lower.

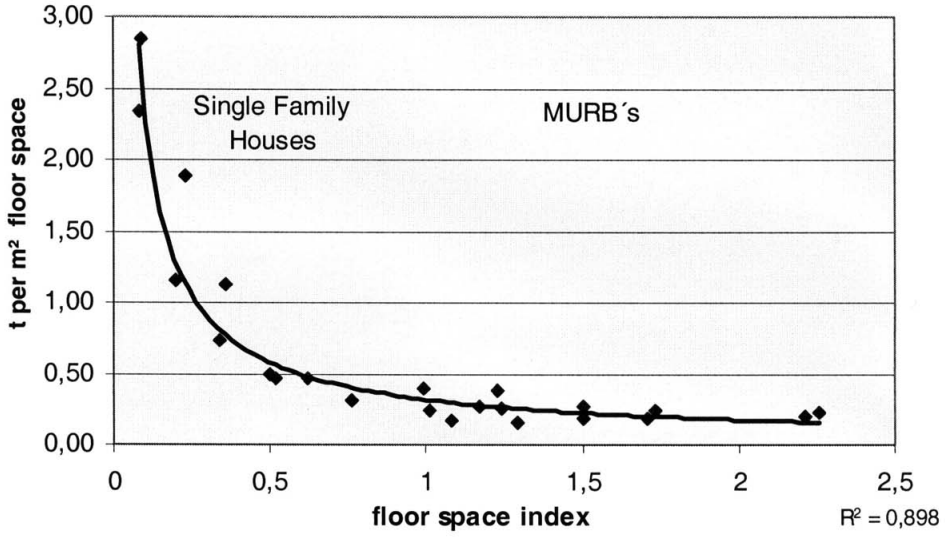


Figure 2: Specific infrastructure induced material mass and floor space index

However, the proportion is not linear. The specific infrastructure material mass is increasing disproportionate in areas with density less then 0,5 (detached single family houses, villas). Reversely, an increasing density has very little effect on the quantity of specific infrastructure material mass (MURB´s[3] areas are characterised with floor space index above 0,5)

Former investigations on the specific size of public thoroughfare and floor space index in built up areas (Gassner et al. 1986; Menkhoff et al. 1979) are supporting the findings shown above. Thus urban density, marked by building types, division of land and arrangement of buildings has central relevance to the specific expenditure on local public infrastructure.

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[1] age, building type, building condition, heat-system, floor space index

[2] Leipzig Freiberg and Zittau

[3] **m**ulti **u**nits **r**esidential **b**uildings

Comparing the specific material stock of buildings and infrastructure facilities, the importance to focus attention on infrastructure induced mass flow is increasing with decreasing density (Figure 3). While in heavy built up areas the specific infrastructure material mass is about 20 % to the specific building mass, in low density built up areas infrastructure induced share of mass flow is more significant (about 60 % to 70 % of the specific building mass in single family housing and villa areas).

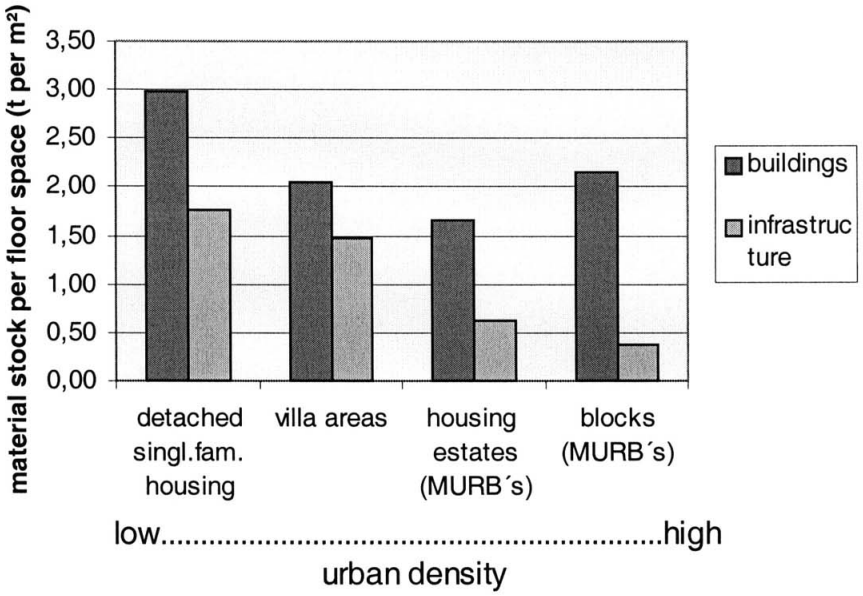

Figure 3: Material mass of buildings and Infrastructure in urban structural units per m²

4 MATERIAL FLOW MODEL CALCULATION

The results of empirical investigations support calculation components to project material flow of building stock within different spatial levels (city, region, state). Calculation components depends on building types, specified along size, construction and age (Gruhler, Schiller, Böhm 2002). In cooperation with colleagues of the Dresden University of Technology[4] current investigations developed a description of typical infrastructure equipment in urban structural units to extrapolate infrastructure induced mass flow. Based on a urban structure density model, dimensions of streets and pipelines where calculated and typically materials where investigated for model areas. The developed infrastructure module is a standardized description of urban structural units, including specific size and construction of public streets and sidewalks, specific lengths and dimensions of pipelines and a classification of infrastructure elements. Infrastructure elements specify material and service life of infrastructure facilities (UBA 2002).

Model calculation of development scenarios of building stock (15 years) (Schiller, Deilmann, Iwanow 2002) indicates results of particular interest: In all regarded development versions, the infrastructure induced material flow is higher in quantity than the material flow caused by buildings. Though the results are unexpected, it is quite simply to explain. Most of buildings material stock is fixed in brick work and fundaments, but the effect of maintenance to building shell is quite a small one. Maintenance of technical infrastructure entails intense and

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complete reconstruction of road superstructure along the length of pipeline. In view of that, main part material flow in infrastructure facilities is caused by maintenance (Figure 4).

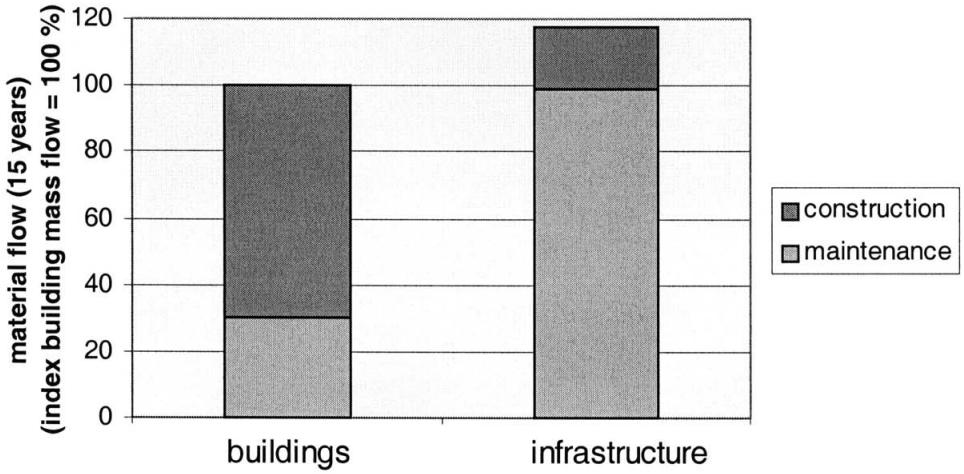

Figure 4: Material flow of development scenarios of building stock - share of construction and maintenance

5 CONCLUSION

The findings underline that more attention has to be paid to urban infrastructure in ecological urban planning. This applies to urban planning overall, but particularly to low density areas, for the specific infrastructure material mass is increasing disproportionate in areas with density less then 0,5 floor space index.

For sustainable development of building stock, it is necessary to focus more attention to maintenance of infrastructure facilities. Model calculation of urban development indicates, that the high material flow caused by infrastructure maintenance.

The urban structure approach provides a suitable frame to picture future developments of built up environment. It is possible to define building types and infrastructure types that allows to project findings on different spatial levels (city, region, state). Nevertheless it is necessary, to redefine the essential boundary conditions (especially mix of building types and floor space index) respectively to the focused spatial plain. Here the IOER research findings provides qualified basics.

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Maximum Environmental Benefit for Money

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1. INTRODUCTION

In Denmark, sustainable buildings have been in focus for a number of years and tools to make systematic environmental assessment have been developed and tested in a number of projects. In this paper, a new tool is presented and the objective is to ensure that limited economic resources are used effectively to reduce the worse environmental impacts and at the same time optimise the economic parameters. In other words: Maximum environmental benefit for money.

2. SYSTEMATISATION RATHER THAN RANDOM SELECTION

Measures to avoid environmental effects are often chosen at random with no assessment of the actual overall environmental benefit. A lot of environmental measures are used in new buildings and renovation because they give a visual effect – for example vegetation roofs, collection of rainwater or use of external wood facades. The builder chooses these measures because of their marketing value as an environmental signal rather than for their actual environmental benefit.

Any reduction in environmental impacts is of course of benefit, but random measures can make the construction and operation of a building more expensive without significant benefit to the environment. This is often the case if no systematic environmental assessment has been carried out prior to construction.

3. ENVIRONMENTAL MANAGEMENT IN PROJECT DESIGN

Implementation of environmental management in the project design ensures that environmental impacts are assessed and environmental goals are defined.

The process starts with an environmental survey followed by a listing of environmental impacts in order of priority and the definition of environmental goals and measures.

3.1 Environmental survey

The environmental survey gives an overview over possible environmental impacts.

The survey is a useful tool to assess the possibilities – for example, a survey of the impacts for several materials is carried out, even though some materials will not be used – the choice of materials being dependent on the evaluation.

The survey can give an indication about potential dangers “environmental threats”, so we can avoid them. All possibilities for the choice of constructions, floor coverings or installations are still open.

We use a checklist to unmask potential environmental impacts in the lifecycle of the building. Furthermore, the most important environmental impacts are identified based on how serious the effects are.

When the survey is finished, the most important environmental impacts are listed.

3.2 List of priority

The result of the ranking is a list of environmental impacts and life cycle phases.

It is nearly impossible to carry out improvements for all of the important environmental impacts and therefore a list of priorities must be made. Normally, 3 to 5 of the top-ranked impacts can be targeted.

The ranking is based on the following evaluation:

- Extent – is the effect global or local?
- Duration – single acute incidents or chronic?
- Reversibility – will the effect disappear with time?
- Amount – small or large emission/consumption?

At the same time, consideration must be given to any special environmental wishes specified by the builder.

3.3 Environmental goals

The next step is to define environmental goals for the top-ranked impacts. The goals should be general, i.e. unspecific with respect to possible measures, but measurable. Otherwise, the planner is denied the freedom and the opportunity to reduce the potential impacts by innovative design. The environmental goals define the framework for the solutions – not the measures.

If the impact is identified as a large consumption of finite energy resources, an environmental goal for the maximum consumption of finite energy resources should be defined. Several very different measures to achieve the goal can then be devised such as walls with a very high insulation value, optimisation of usage of floor area (reduction in the size of the building) or use of solar energy. All solutions are equally appropriate.

3.4 Environmental measures

The measures to fulfil the goals can be of a technical nature or due to a change in behaviour and habits. If the goal is to reduce the consumption of finite energy resources, the following measures could be appropriate:

- Lower room temperature
- Use of another energy resource
- More insulation
- Balanced ventilation system with heat recovery
- Smaller apartments/dwellings

The different measures can contribute individually or collectively to fulfilment of the environmental goal. But which measures should be chosen?

4. CHOICE OF MEASURES

Choice of measures requires optimisation of two aspects: The environment and the economic restraints. Furthermore, the measures must be technical possible for the actual building.

We prepare a list of potential measures that can fulfil the environmental goals as well as an assessment of the economy for each measure during the lifetime of the building. The measures are ranked in a scheme, which can be used during decision making by the builder.

It is important to put every possible relevant measure in the scheme. The next step is to assess which measures are technically and economically possible for the actual project. In this way, aspects taken into consideration during the assessment of measures and the extent to which the environmental goals can be fulfilled can be documented. An example illustrating the assessment and choice of measures is given in table 2.

The fulfilment of an environmental goal is defined as:

Table 1 Definition of fulfilment of environmental goals

Interval	*Explanation*
81-100%	The measure gives a very good fulfilment of the goal
61-80%	The measure gives a reasonable fulfilment of the goal
41-60%	The measure gives a fair fulfilment of the goal
21-40%	The measure gives a poor fulfilment of the goal
0-20%	The measure gives a very poor fulfilment of the goal

The assessment of degree of fulfilment of an environmental goal is of course uncertain and can be estimated as a % or as an interval.

The assessment is made in relation to the traditional solution, e.g. low energy equipment is compared with normal equipment, natural ventilation is compared with mechanical ventilation, etc.

The assessment is based on a rough estimate – expert opinion can be requested if the assumptions for the assessment are uncertain, but no measurements or calculations are made at this stage in the process.

The method is very useful to reduce the number of alternatives so that an in depth assessment of the few most promising measures can be made.

To ensure an overview, the descriptions of the measures are concise.

Table 2 Assessment of measures

Environmental goal: *The consumption of finite energy resources must be less than 10.000 kWh/Y* *(Apartment with a floor area of 150 m^2, estimated life span of 60 years)*							
				Building lifetime economy*			
Chosen	Not chosen	**Measure**	**Fulfilment of environmental goal**	Establishing	Operation	Disposal	Total
	X	Reduction of area to 100 m^2	100%	CC	CC	C	CC
X		Division in zones and optimisation of room usage according.	30%	-	CC	C	C
X		Active solar energy (sun panels)	30%	E	C	E	-
	X	Active solar energy (sun cells)	30%	E	C	E	-
X		Hybrid ventilation – combination of natural and mechanical ventilation	25%	-	C	-	C
	X	Pre warming /cooling of ventilation air through channels in the earth	20%	EE	C	E	E
X		Low energy windows, U=1,4	10%	E	C	-	-
X		Heat recovery on emissions from ventilation units	30%	E	C	E	C
	X	25% better insulation	10%	E	C	E	C
	X	Wind energy	81-100%	E	C	E	-

* EE ~ Much more expensive, E ~ More expensive, - ~ Neutral, C ~ Cheaper, CC Much cheaper

The choice of measures to be used in the project is determined by the assessment of the fulfilment of environmental goals together with their total economy for the building's lifetime.

After preparation of the scheme, the builder might due to reasons unrelated to the environment goals or to economy reject some of these measures. The choice of measures from among the remaining measures in the scheme is taken based on the following principles:

First choice is the selection of the measures that are much cheaper than the traditional constructions and contribute to fulfilment of the environmental goal. Then measures that are cheaper and still contribute to fulfilment of the environmental goal are selected. At this point all the chosen measures have contributed to a cheaper project (with respect to the lifetime economy of the building) and at the same time have reduced the environmental impacts.

Further measures may be necessary if the environmental goals are still not met, and this might require a more detailed assessment since the % fulfilment can not directly be summated due to overlap. The process is continued until the environmental goals are fulfilled or the economic resources are used.

5. EVALUATION CONCERNING THE FULFILMENT OF THE ENVIRONMENTAL GOALS

Environmental management has been initiated to some extent in some building projects, but the choice of measures (specific initiatives to reduce the environmental impacts), and the extent to which these measures fulfil the goals for the actual building are seldom assessed.

The extend to which the goals are fulfilled can be presented by the "spider" illustration.

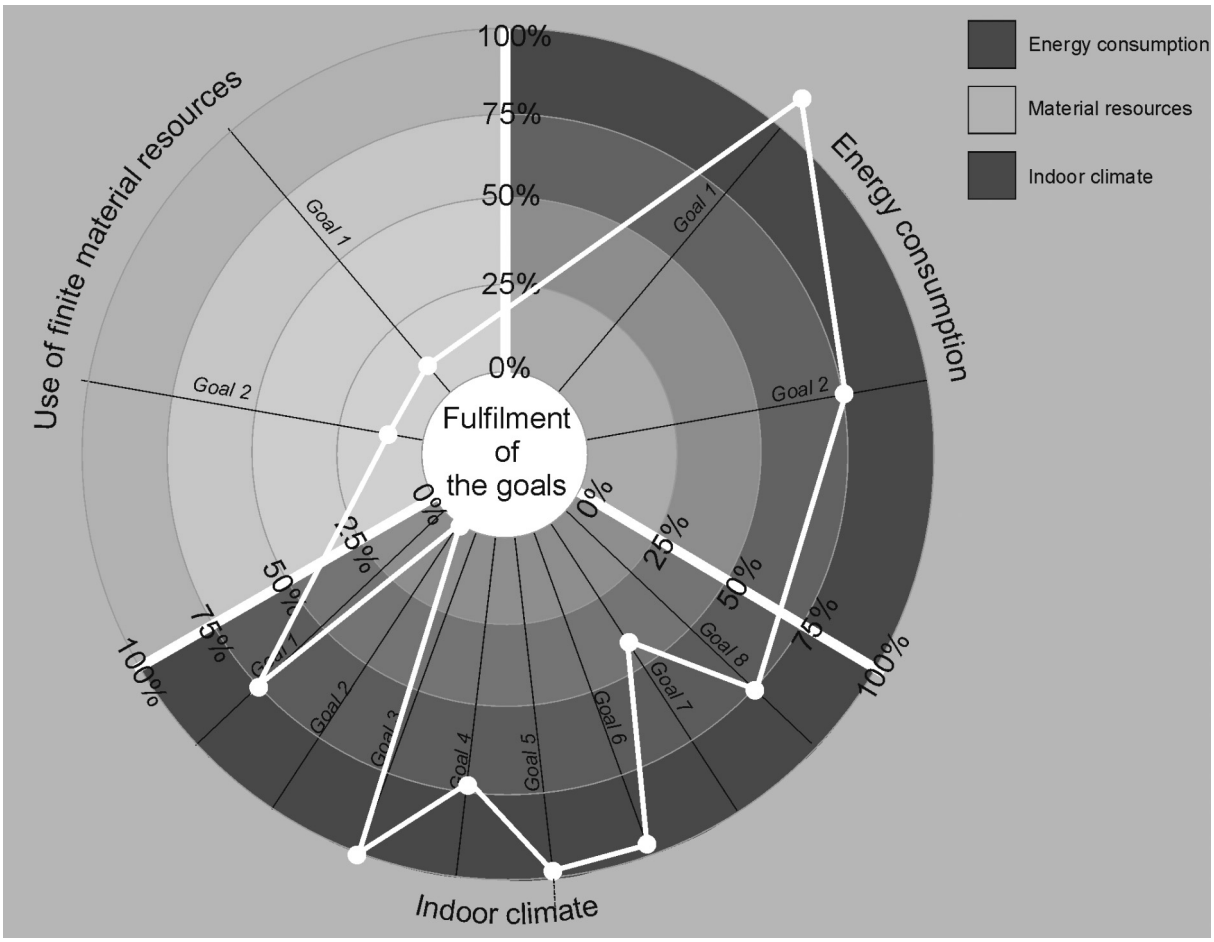

Figure 1 "Spider" illustration

The circle is dealt in 3 segments allocated to the 3 environmental impacts that have the highest priority; in this example, energy consumption, indoor climate and use of finite material resources. In each impact segment, radii are drawn corresponding to the different environmental goals. The degree of fulfilment of the goals is illustrated by a curve drawn cutting the radius for each goal. The distance from the centre along the radius shows the degree of fulfilment of the goal.

The estimate for fulfilment of an environmental goal can not be directly compared for different measures or represented by a simple summation. Some measures exclude each other, e.g. natural ventilation and heat recovery; others will affect the estimated individual effect, e.g. use of heat recovery means that low energy windows “save” less energy than if heat recovery was not used.

Summation is therefore incorrect, but is sometimes applied to give an indication of the number of measures required to achieve the environmental goals.

5.1 Future

This paper has described a tool to assess measures to manage environmental impacts under planning, establishment, operation and demolition. It is only one of several initiatives required if the building sector is to produce sustainable buildings.

Two other very important initiatives, which would give more quality to buildings and improve the environment, are changes in co-operation between stakeholders and value management.

Energy Efficient Single-Family houses for Smart People

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Introduction - Bo01 – The Town of the Future

The energy supply for Bo01's "*ecologically sustainable information and welfare community,*" which was built in record time in the Western Harbor in Malmö, will be from 100 percent locally produced, renewable energy. A heat pump brings energy from seawater and aquifers, and raises its temperature level. A district heating network distributes the energy required for heating and water heating within the area. The district heating network also receives additional energy from solar panels, which have been installed on a number of buildings in the Bo01 area. Domestic electricity and electricity for running the heat pump is generated using mainly wind generators, and to a smaller extent electricity from solar cells. In order to achieve the goal of 100 percent renewable energy, a balance is needed between the production and use of electricity as it varies throughout the year. This will be achieved by linking the area's network with the City of Malmö electricity and district-heating network to allow the evening out of shortfalls and surpluses over the coarse of the year.

In accordance with Bo01's *Quality Program*, the average annual energy use for the area may not exceed 105 kWh/m^2 in order to be able to achieve a balance. The document states that this ratio should include all property-related energy, plus energy that is produced or recovered within the properties. When the area is completed, energy use and comfort will be evaluated over two complete annual cycles.

The Swedish National Energy Agency's Requirements for Energy Efficiency for Single Family Buildings

While evaluating the technology procurement competition, "*The 21st Century House,*" the idea developed to use the experience from the evaluation and allow creative house builders the opportunity to build one or two houses at Bo01. The houses should fulfill the Energy Agency's requirements specification for energy efficiency and a healthy indoor climate. The size should be suitable for the needs of a normal size family. As the houses will be part of a housing fair, which is expected to attract a large numbers of visitors, this would be an excellent opportunity to inform the public about the Energy Agency's recommendations for building efficient, environmentally friendly and economical homes.

A steering committee appointed by the Energy Agency has formulated the requirements for energy efficiency. In light of the Swedish Environmental Goals Committee's proposals for limiting energy use in new dwellings and the climate in Malmö, which is considerably milder than the average Swedish climate, the steering group agreed to make the requirements more

stringent, from Bo01's 105 kWh/m^2 to 100 kWh/m^2 of purchased energy for houses heated using district-heating, and to 80 kWh/m^2 of purchased energy for electrically heated houses. These values include all energy that is used in the houses, i.e. in addition to heating and ventilation, also energy for domestic hot water, domestic electricity and other electricity used in the houses. It has been assumed that use of hot water, appliances and other electricity in the houses will reflect normal use. In addition, a comfortable temperature and good air quality should be provided. The residents should be able to use their houses normally, but should not consume too much energy. These requirements, as well as requirements for flexibility to enable the installation of different systems, a standard size of around 130 m^2 BRA, and the ability to build the houses with a modest increase in cost are the Energy Agency's basic motives for participating in Bo01.

The level of insulation and the design of the building envelope will have a crucial influence on energy use throughout the life of a building. The additional cost of increased insulation thickness and good airtightness is modest for new construction – especially if in the future it becomes standard for all buildings. Adding extra insulation later or trying to make a leaky building airtight has proven to be so costly that the payoff time is considerably longer than the probable life of the building . A well insulated and airtight building envelope can be considered almost completely maintenance free, and is a fundamental requirement for an energy efficient home of the future and that will hopefully function well for a very long time. Installations and appliances must also be chosen with regard to the low heating demand that an effective building envelope creates, so that the relatively greater proportion of additional energy from processes, people and unpredictable sunlight can be utilized. It should be possible to carry out maintenance and replace parts without excess impact on the building.

Other Requirements from the Energy Agency

The following condensed and edited list shows the Energy Agency's requirements that go beyond the more general requirements:

- The buildings should be designed so that they can be built throughout the country. This means that the design should allow for the use of a variety of different heating systems. The architecture can vary as long as the same functional requirements are met.
- The buildings should be quality assured during their construction, so that no faults and deficiencies are built in, e.g. moisture and unnecessary thermal bridges.
- The buildings should maintain a good indoor climate.
- All appliances should be class A.
- The windows should have a U value of no more than 1.0 W/(m^2·K). The daylight transmittance should be at least 63% and the solar energy transmittance at least 52%.
- In places where there is fixed lighting, fittings for compact fluorescent lamps with pins should be installed.
- Heating should be provided by a hot water system with radiators. The flow temperature of the heating water should be controlled by an outdoor thermostat, and the heat output of the radiators should be controlled by thermostats, so that solar heat gain, people and processes is utilized. The

control system should make it possible to set the indoor temperature within a range of at least ±3 °C of +20 °C. The radiator valves should close fully when the actual temperature exceeds the set value by 0.5 °C. The control system should normally be able to maintain the set temperature level within the limits ±0.3 °C when heating is required.

- So called P-marked products should be used as much as possible. The Swedish Testing and Research Institute (SP) accredits the marking.
- The heat exchange should be one of the winners of the Energy Agency's competition.

Brief Description of the Two Houses and their Systems

The two companies, *LB-Hus* and *Yxhult AB*, have produced solutions that are differ from each other, but which were judged to fulfill the Energy Agency's specifications. *LB-Hus* chose to use exclusively electricity in the house, while *Yxhult* has opted to use district heating for heating and hot water. As a result, *LB-Hus* will be able to keep the total annual purchased energy use below 80 kWh/m^2, and *Yxhult* will use less than 100 kWh/m^2

Both of the houses have been built with two floors, and accommodate the city development plan's somewhat unusual restriction limiting the area of the upper floor to no more than 60 percent of the area of the ground floor. Both of the companies have chosen to have somewhat higher ceilings than is customary. This, combined with the requirements in the city development plan, has led to the surface area being 10 % larger per m^2 of floor area than would be required with lower ceilings and without the restrictions imposed by the city development plan. Heat loss through the building shell will thus be equivalently larger.

Both of the companies initially chose to achieve energy efficiency by using and to some extent improving on basic techniques. Based on the basic requirements for timber or lightweight concrete buildings, they have built well insulated houses with good detailed building solutions, so that extra heat loss through thermal bridges is limited and very good airtightness is achieved. Great importance has also been put on choosing a heating system that has little thermal inertia and a temperature control system that reacts quickly to changes in heating demand. In particular, the supply of heat is able to be cut off very quickly when the indoor temperature rises due to additional heat from the sun, large internal heat sources, etc.

Both of the houses also have a small utility building, although these are not covered by special requirements for energy efficiency.

The *LB-hus'* house has a heated floor area of 137.8 m^2, a timber framework insulated with 30 cm of mineral wool, a ground slab with 30-35 cm of cellular plastic insulation underneath, a hot water heating system with radiators, mechanical exhaust air ventilation (including exhaustion in bedrooms) and an exhaust-air heat pump, which recovers energy from the exhaust air for both the heating system and domestic hot water. During periods of high demand, additional heat is obtained from an electric heater.

The *Yxhult* house has a heated floor area of 149.4 m^2; a framework, including inside walls and staircase, of lightweight concrete (Ytong), outside walls of 45 cm low density, lightweight concrete, a terrace floor structure insulated with cellular plastic, an upper floor insulated with loose-fill cellulose fiber, a hot water heating system with radiators, and mechanical exhaust and supply air ventilation with heat recovery. The crawl-space under the ground floor is

ventilated by indoor air, and the ground and foundation walls are insulated with 20 cm cellular plastic. Energy for heating and hot water is obtained via a heat exchanger from the district-heating network.

Energy Use Forecast for the Two Houses

The expected energy consumption for the two houses has been estimated using the ENORM software. Consequently, the estimated requirement forecasts for purchased energy for the two houses, which are shown in Table 1, contain several mean values based on statistics and on rather uncertain assumptions. For a specific house, year and family, the actual energy consumption will deviate from the forecast.

Table 1 Estimated energy use, recovered and utilized "free heat" and purchased energy in the two houses

	kWh/annum	
Energy use	***LB-Hus***	***Yxhult***
Heat transfer through floors, walls, roof and windows	9,850	12,600
Ventilation	6,850	6,700
Air leakage	0	400
Hot water	4,300	4,300
Electricity for fans and pumps	800	1,750
Domestic electricity	3,000	3,000
Recovered and utilized "free heat"		
Heat recovered by the heat pump	7,750	
Heat recovered by the ventilation heat exchanger		4,350
Heat from sunshine	2,700	5,200
Heat from people	900	800
Heat from white goods and fans	2,400	3,500
Total purchased electricity	11,100	4,800
Total purchased district heating		10,100
Grand total	11,100	14,900

Below are some notes on the choice of input data and how these choices can affect the outcome.

- Heat transfer (floors, walls, roof and windows): The total loss is estimated using UA values supplied by each manufacturer, based on an indoor temperature of + 20°C and the average annual outdoor temperature for the Malmö climate. The result is affected by discrepancies in UA values, indoor temperatures and the outdoor temperature of the particular year. In the estimates, additions have been made for known thermal bridges.
- Ventilation: The estimates apply for the specified air exchange, in accordance with the Swedish Building Regulation's minimum requirements, at an indoor temperature of + 20

^{o}C and the average annual outdoor temperature for the Malmö climate. The result is affected by deviations in air exchange setting, indoor temperature and the outdoor temperature for the particular year.

- Air leakage: With the stipulated airtightness requirement for the building envelope, air leakage should be zero in the mechanical exhaust ventilated *LB-hus* house, since even air leakage through constructional elements is included in the specified exhaust airflow. Because the house is very airtight, there will probably almost always be a negative indoor pressure relative to the outdoor pressure. The air leakage is also expected to be almost negligible in the balanced ventilation *Yxhult* house, which is also very airtight. An element of uncertainty is how often windows will be opened for ventilation during the periods when heating is required. However, we have assumed that this will have a negligible effect on heat consumption.
- Hot water: Consumption has been assumed to be the same for the two houses, but depends, of course, on how much each family uses. For the *Yxhult* house, every kilowatt hour of hot water energy saved is fully effective, while for the *LB-Hus* house, the energy requirement is reduced by only a third, as long as the output of the exhaust-air heat pump is sufficient for both heating and hot water requirements. Using low-flush fittings and toilet pans, consumption of cold water should be lower than in average houses.
- Electricity for fans and pumps: The major difference between the two houses is due to the fact that the balanced ventilation system in the *Yxhult* house, in combination with the warm crawl space, requires three fans, while the mechanical exhaust system in the LB house manages with just one fan.
- Domestic electricity: Estimated consumption is the same for both houses. The use of energy efficient white goods and low energy light bulbs has been accounted for. However, a factor of uncertainty is whether increased use of home computers and other modern electrical equipment will nullify some of the savings of energy efficient white goods.
- Heat recovered from the heat pump: This calculation is based on figures from tests carried out at the Swedish Testing and Research Institute (SP). In order to obtain the estimated heat recovery from the exhaust air using a heat pump, approximately 2,800 kWh of energy is needed to run the compressor. The operation and maintenance of the heat pump will effect how its function can be sustained in the long term.
- Heat recovered from the ventilation heat exchanger: This calculation is based on figures from tests at SP. The fact that the temperature of the exhaust air is reduced by a few degrees in the crawl-space before it reaches the heat exchanger unit and the imbalance that is necessary to create a stable negative pressure in the house are accounted for. To maintain the efficiency of the heat exchanger, its filters must be cleaned and/or changed regularly.
- Utilized "free heat" from solar: The explanation for the major difference between the two houses is that the *LB-hus*, has the living room side, which has the greatest number of windows, facing north due to the design specifications in the city development plan, while the *Yxhult* house has the living room side and the large windows on the upper floor facing south. An additional factor is that the *Yxhult* house has an approximately 70% larger glazed area than the *LB-hus*. We are not at all sure how much of the solar heat can actually be utilized. Some of the sunlight is screened by surrounding houses and trees, some intentionally with awnings and venetian blinds. In addition, the heating and the control systems need to be flexible enough to utilize the additional heat without making the temperature uncomfortably high. The estimated additional heat from sunlight plays an important role in the energy balance.

- Utilized "free heat" from people: These values are based on statistics and depend on the size of the family and how much time the family members spend in the house. The actual result can deviate considerably, in relative terms, from the stipulated standard values, but because the absolute value is small, the deviations only have a small effect on the total requirement for purchased energy.
- Utilized "free heat" from white goods: The difference between the two houses in terms of free heat from white goods is mainly due to the fact that the intake air fan and one of the two exhaust air fans in the *Yxhult* house also provide additional heat during the heating period. Compared with additional heat from solar, this heat is more evenly distributed and, as long as the heating and control systems are correctly set, deviations are mainly due to differences in the habits of the occupants. However, we judge the reliability of this estimate to be relatively good. In our estimate of heat consumption, we take account of the fact that energy efficient white goods are used, which means that they will contribute less heat than would normally be the case. It is worth noting that a correction of this type is not normally made in energy calculations using ENORM.

Evaluating and Following Up

The energy use of the houses will be evaluated over a complete annual cycle, with people living in the houses. As described above, the total energy use depends on many interacting factors, several of which the users can influence. It is of considerable scientific interest to evaluate the houses with their users, as we are very interested in knowing how humans and technology can interact. The aim of the evaluation is to attempt to distinguish between purely technical characteristics and the effect of behavior, and also to attempt to analyze how the interplay between humans and technology influences the results.

Conclusions

The two houses at Bo01 are examples of how energy efficiency can be achieved by applying the best available technology that can be obtained at a reasonable additional cost. It is also assumed that the houses will not need to be maintained differently from ordinary newly-built houses. The occupants should be able to live as they want to, without energy use being too high. The indoor climate should be pleasant, with a good and healthy air quality. In other words, the aim is to show what is economically plausible and not what is technically possible. We think that it should be possible to incorporate the technical and other solutions used in the two houses into standard production of new houses. If the technology becomes standard, the additional cost should be reasonable. There is already technology available that can be used to build houses that meet the future required levels for energy use. There is absolutely no reason to delay implementing better and more energy efficient building techniques in standard production, in order to achieve the highest energy goals.

The two houses demonstrate that extremely low total energy use can be achieved using just electricity, so low that it is difficult to justify any other energy source, and that proportionately low electricity use can be achieved with a relatively higher heat consumption. This heat may well be obtained from renewable fuel.

Impacts of a Green Building Rating System on the Design and Construction Process: A Summary of Ten Projects Using LEED™

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1. INTRODUCTION

This paper discusses the experience of developing designs for, and the specific sustainability approaches taken by, ten buildings that have used the US Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED™) Green Building Rating System. It identifies the principal ways that LEED™ influenced the design, including the addition of sustainability features, of each of the buildings relative to the design that would otherwise have been produced by "standard practice." It provides a generalization of lessons learned from the projects and describes the extent of market transformation achieved through the LEED™ process.

2. TEN LEED™ BUILDINGS

The ten LEED™ buildings are described in Table 1. Seven of the buildings are currently either in the design phase or under construction; the other three are now fully occupied. Two of the buildings are already officially certified by the USGBC at the "Certified" level. The rest of the buildings are still in the certification process, so the LEED™ level shown is not official. Four buildings intend to achieve the highest LEED™ level of "Platinum," and the last four intend to achieve "Silver" certification. The table lists the major sustainability project features, in the LEED™ system categories: Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, Indoor Environmental Quality, and Innovation & Design Process.

Construction types include new, renovation, expansion, and tenant interior work. The buildings range in size from 455 m^2 to 57,000 m^2 (5,000 to 630,000 square feet) in floor area. Sites include urban and rural areas, as well as a degraded urban city park. Building owners include local and federal government agencies, non-profit and environmental organizations, and major corporations.

2.1 Original Project Designs

The original "base case" project designs for the buildings all included a certain degree of sustainability. Some of the projects by environmentally sophisticated owners would have included some sustainability measures regardless of whether the LEED™ rating system was used or not, as shown in the Base Case. However, as a result of using the LEED™ rating system, these projects have added additional sustainability measures that they otherwise may not have.

Sustainable design is new to the corporate, for-profit owners of the projects. The LEED™ rating system provided them with a valuable tool to evaluate the most cost-effective sustainability measures to include in their projects. This relative cost-effectiveness metric (cost per LEED™ credit) is a key determining factor for decision-making in the corporate world.

2.2 Sustainable Design Review and the Decision Making Process

For each building, determining which sustainability measures to include required close coordination between the entire project team – owner, designers, contractors and consultants. Generally the team determines which sustainability measures to include in the design as a minimum in the design, meaning those measures that are the most cost effective or required by local regulations. The team then identifies a number of added potential sustainability measures, usually more than are required to achieve the desired LEED™ goal, that might possibly be included in the project, but that require further review to determine their cost effectiveness and feasibility. LEED™ measures are also identified and eliminated that do not apply to the project and do not merit further discussion (e.g. Is the project site in a flood zone? If so, the project will not qualify for the LEED™ Site Selection credit, so this credit can be eliminated). From the list of measures used by each project in Table 1, it can be seen that different projects take widely different approaches to the LEED™ goal. This is reflective of the unique issues, constraints, and opportunities for each project.

A key finding is that unless the design team *integrates* the various sustainable design measures, the cost of achieving the desired level of LEED™ will be higher than otherwise. However, the required types and degrees of integration of "whole building" issues are foreign to standard design practice in the US, and require substantial attention to be successfully achieved.

2.3 Sustainable Design and Construction Implementation

Once the project team has determined which sustainability measures to include in the design, it falls to the design and construction teams to incorporate them into the building. It is not unusual for a project to lose some of its planned sustainability measures during this process. This may occur due to difficulties with product availability (e.g. a goal of using only wood grown in environmentally managed forests may be infeasible due to supply constraints) or inattention to specifications by construction trades (e.g. failure to use adhesives without Volatile Organic Compounds ("VOC's")). As a result, it is recommended that the project team provide a sustainability contingency buffer of "extra" LEED™ credits to account for these types of situations; otherwise, the project goal of achieving LEED™ certification may be jeopardized. It has been found that the threat of failure to achieve LEED™ certification is a crucial enforcement factor in achieving sustainability compliance. However, even with this leverage, compliance failures occur. It has been found that using a neutral third party, such as the LEED Consultant and/or the Commissioning Authority, to track the construction compliance issues, substantially improves success in this.

2.4 Documenting the Sustainability Design Measures

The final step in building a sustainable project and in achieving official LEED™ certification is documenting that the specified sustainability measures were actually built into the project. This documentation is often the most difficult part of the LEED™ sustainability process, as providing the required documentation paperwork is not a process with which most contractors are familiar. Even with the best of intentions, often the required documentation is not

provided. Again, coordination among the members of the project team is of the utmost importance. If the actual installation of the sustainability measures cannot be properly documented, then the measure cannot be claimed as actually installed in the project. LEED™ is structured in such a way that it is very difficult, and not cost effective, to include sustainability measures that are design-based only. Construction compliance is a key issue, and documentation of how fully the specified sustainability process was followed is essential. Without this element of "proof of compliance", the LEED™ objectives of achieving an actual green building as constructed would not be achieved.

3. MARKET TRANSFORMATION

Every phase of the building design and construction process is affected by the application of the LEED™ system. This has both required and created a transformation in the marketplace, as follows:

- **Owners** have had to assess the value of the LEED™ rating, to determine the costs and benefits of having a LEED™ rating, and to understand the impact that it has on the building process. As this has occurred, many owners have set criteria for selection of Design Teams that require knowledge and experience with LEED™. This evolution is at an early stage, with government and non-profit organizations leading the way; only a few for-profit entities are yet applying LEED™, and that primarily for owner-occupied facilities.
- **Architects and Engineers** have had to learn the technical requirements of LEED™ and identify cost-effective ways of meeting and documenting those requirements, and to develop a revised design process which incorporates those requirements in an integrated fashion. This transformation is also at an early stage, although almost all A&E's have now been confronted with LEED™ as an issue.
- **Contractors** (both General and specific sub-trades) have had to learn how to accommodate the various construction-phase requirements of LEED™ in cost-effective ways and how to document compliance with LEED™. The need for orientation and training of the various members of the construction team in these issues has become clear. Given the relatively few projects that have yet been constructed using LEED™, the contracting community is the least far along in its adoption of and familiarity with LEED™.
- All three groups have had to become aware of the role of the **LEED Consultant** and the **Commissioning Authority** as project participants with unique perspectives on delivering project performance which is *measured* and *documented*.

4. ENVIRONMENTAL IMPACTS

The environmental impacts of applying LEED™ to the buildings are summarized in the graphs in Table 2. This table shows how eight of the ten buildings reduced the use of energy, water and landfill wastes, in almost all cases by a significant margin. The average reductions for these projects were: Energy usage 44%, Water Usage 41%, and Construction Waste 84%. These reductions are relative to the "base case" which is cited for each in Table 2.

5. CONCLUSIONS

Although LEED™ is still at an early stage of use, it is transforming the building design and construction market in environmentally significant ways.

- Environmental issues are now a focused discussion topic from the onset of project design.
- The use of the LEED™ rating metric as a project goal is very motivating and unifying: the Owner adopts the goal, and all Designers and Contractors become bound by it.

- LEED™ encourages a more integrated design and construction process among all the members of the project team, in order to achieve the LEED™ goal cost-effectively.
- LEED™ broadens the topics of discussion to many areas of environmental impact not previously considered at all in standard design and construction practice.
- Evaluation of the "base case" design, which is mandatory in determining what changes to the design and process are required to achieve the LEED™ rating, raises team technical understanding of key issues in a variety of environmental domains (beyond energy alone).
- The LEED™ requirements for commissioning and compliance documentation motivate the project team to continue its coordination to the end of the construction process.

6. REFERENCES

No published references. The data in Tables 1 and 2 utilize technical project data prepared by the authors' firm for the specific projects being discussed.

Canada's Commercial Building Incentive Program: Impact on Energy Consumption

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1. INTRODUCTION

Following the adoption of the Kyoto Protocol in December 1997 by 160 participating nations, Canada set in place a national process to examine the implications of Kyoto and possible implementation options to meet the objectives of the agreement. Canada agreed to reduce its greenhouse gas (GHG) emissions by 6% from 1990 levels within the period of 2008-2012. One of Canada's initial commitments to addressing climate change and reducing GHG emissions was reflected in the Government's 1998 allocation of $150 million over three years to a Climate Change Action Fund. The Commercial Building Incentive Program (CBIP) was one of many programs that was initiated in 1998 as a direct response to the Kyoto Protocol.

This paper will examine the energy simulation data of CBIP projects from phase I of the program which spanned from April 1,1998 to March 31, 2001. Energy consumption and GHG savings data for CBIP buildings will be compared to conventional buildings and buildings built to the Model National Energy Code for Buildings (MNECB) standard in order to assess CBIP's impact on energy consumption and its contribution to reducing GHG emissions.

2. COMMERCIAL BUILDING INCENTIVE PROGRAM

The objective of CBIP is to encourage the incorporation of energy efficient measures into the design and construction of new commercial, institutional and multi-unit residential buildings in order to contribute to the reduction of GHG emissions in the commercial sector. Building owners are eligible for a financial incentive if their building design is at least 25% more energy efficient than a similar building built to the level of the MNECB, which specifies minimum energy performance standards for the construction of new buildings in Canada. The CBIP incentive is based on the annual energy savings calculated as the difference between the owner's proposed building and the MNECB reference building. The energy consumption for both buildings is calculated using EE4-CBIP which is an energy analysis software tool developed by the Department of Natural Resources Canada to demonstrate CBIP compliance. The EE4-CBIP software uses the United States Department of Energy's DOE-2.1 software as the calculation engine to generate the energy performance results.

3. OVERVIEW OF RESULTS

3.1 Projects from 1998-2001

At the end of phase I of CBIP 101 projects had received a financial incentive from the program ranging from $1,300 to $80,000 for a total amount of $4.1 million. CBIP buildings realized an average energy savings of 32.2% [1] better than the MNECB standard which exceeds the required 25% level set out by CBIP. Below are some of the statistics you will find in Figures 1 to 3:

- The average energy intensity of a CBIP building is 233 kWh/m² which is 32.1% lower than

the MNECB building and 53.6% lower than a conventional building.

- The average energy intensity of an MNECB building is 31.6% lower than a conventional building.
- A total energy savings of 60,053 MWh was saved between 1998-2001 which amounts to a $2 million cost savings.

[1] All CBIP and MNECB average data are weighted values against floor space.

- A total GHG reduction of 14,044 tonnes was saved between 1998-2001 which is equivalent to the emissions saved by removing 4,681 cars from the road.

- CBIP Phase I achieved a cumulative energy savings of 84,194 MWh and a cumulative GHG savings of 18,928 tonnes which is equivalent to the emissions saved by removing 6,309 cars from the road.

Intensities of Environmental Loads based on 1995 Input/Output Table in Japan

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ABSTRACT

Energy, CO2 emission, air pollution (NOx, SOx, Dust), water pollution (BOD, COD, SS), industrial waste and ELU(Environmental Loading Units) are derived from the 1995 Japan input/output (I/O) table and the quantity of material table. These are then used to derive a building material intensities table. The values for these environmental loads are compared to those corresponding values calculated over the lifecycle of a reference office building. Note that though 65% of energy and CO2 emission is caused by operation of the building, 50-95% of air/water pollution and ELU is caused by construction of the building.

1. INTRODUCTION

Input/output (I/O) tables have been published every five years since 1955 in Japan, together with quantity of material tables, employment tables and other collateral tables. Industrial sectors in a country are very closely related, and the input or output of one industrial sector has repercussions on all other industrial sectors. Environmental loads caused by an economic demand value of 1 million yen (1 Euro=115 yen) for an industrial sector can be derived from the input/output and quantity of material tables. Environmental loads due to construction and operation of a building can be calculated from the estimation document for the construction, operation and demolition of the building and the intensity tables.

2. ANALYSIS WITH INPUT/OUTPUT TABLE

The I/O table consists of 397 industrial sectors and the quantity of materials table consists of 134 materials with their corresponding monetary cost. In this report demand for an industrial sector is defined as the buyer price, and this includes the producer price and distribution margin costs like transportation, storage and commercial margin. The mean values of the distribution margin are shown in I/O table. In this report the Leontief inversion is defined as

follows:

$$\mathbf{X} = (\mathbf{I} - (\mathbf{I} - \mathbf{M}) \mathbf{A})^{-1} ((\mathbf{I} - \mathbf{M}) \mathbf{Y} + \mathbf{E}) \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

X : Domestic production (yen/year) **I** : Unit matrix(-)
A : Activities(-)
Yi, Ei : Final demand and exports (yen/year)
Mi : Import of industrial sector i(yen/year)
Ci : Domestic production + Import – Export of industrial sector i(yen/year)

Domestic production **X,** calculated by inputting **Y** (1 million yen, 115yen=1Euro) shows the ultimate domestic production including the repercussion effect. Environmental load can be calculated by multiplying the domestic production **X,** by the calorific value or the CO2 emission value of various fuels, or the environmental load unit per value of production in various industrial sectors.

3. INTENSITIES OF INDUSTRIAL SECTORS

Table 1 shows calorific and CO2 emission values of various fuels used in the quantity of material table. Table 2 shows NOx emission factors for the transportation sector. In Japan, air/water pollution emission factors as well as industrial waste are provided as measured values per industrial sector. Assuming that these environmental loads are proportional to the domestic production of each sector, the environmental loads due to a 1 million yen economic demand are calculated.

Table 3 shows intensities of environmental loads of representative industrial sectors with as relates to the construction and operation of their respective buildings. Table 4 shows comparison of energy/CO2 intensities between steel produced by convert furnace and electrical furnace. In Japan, reinforced steel is defined as steel recycled by electrical furnace and shape steel is virgin steel made by convert furnace. The environmental loads of recycled steel are 40% those of virgin steel.

The total CO2 emission in Japan is estimated to be 357million t-C/, of which construction work, including both building and civil engineering, make up 19.2% and operation of buildings, 23.2%.

4. ELU (ENVIRONMENTAL LOADING UNIT)

The EPS method developed in Sweden (reference 1.) adopted the amount of money index as a

representative of various environmental loads. Examples of units of ELU are shown in Table 4, and the ELUs for building construction have been calculated using environmental loads in table 3.

Figure 1 shows comparison of life cycle environmental loads due to construction and operation of an office building with 1145 m^2 of the floor area. The life of the building is assumed to be 30 years. Energy and CO2 emission due to the operation of the building make up to more than 65 % and the rest is due to construction. Air pollution due to the construction is approximately 50%, and water pollution, 95%. Quantity of materials due to the construction is 65 %, most of which is steel, concrete, coal and crude oil. The proportion of ELU is similar to the quantity of materials and the price in the estimation document.

5. CONCLUSION

Intensities of energy, CO2, air pollutions water pollution, industrial waste and ELU of 397 industrial sectors in Japan are derived using Input/Output analysis. Though energy and CO2 emission due to operation cover 65% of life cycle analysis, air/water pollutions, quantity of materials used for the building and ELU due to the construction cover between 50% and 95%.

REFERENCE

Bengt Steen, Chalmers University of Technology, Environmental Systems Analysis : A systematic approach to environmental priority strategies in product development(EPS). Version 2000-Models and date of the default method, CPM report 1999.5, http://www.cpm.chalmers.se/cpm/public/publicat.htm

Table 1. Calorific and CO2 emission values for fuels

Fuels	Calorific value (KJ/)	CO2 emission value (kg-C/)
Coking coal	29,260 /kg	0.6920 /kg
Steam coal, lignite	29,260 /kg	0.7228 /kg
Crude oil	38,720 /litter	0.7225 /litter
Natural gas	41,023 /m^3	0.5526 /m^3
Gasoline	35,162 /litter	0.6433 /litter
Jet fuel oils	36,418 /litter	0.6669 /litter
Kerosene	37,255 /litter	0.6896 /litter
Light oils	38,511 /litter	0.7212 /litter
Heavy oils A	38,930 /litter	0.7357 /litter
Heavy oils B and C	41,023 /litter	0.8016 /litter
LPG	50,232 /kg	0.8200 /litter
Coke	30,139 /kg	0.8856 /litter

Table 2. NOx emission factors of transportations

Transportation	NOx emission factor
Passenger car	2.93 g/litter
Auto-truck	17.35 g/litter
Ship	2.10 g/litter
Aircraft	0.294 g/litter
Construction machine	53.0 g/litter

Table 3. Environmental loads of industrial sectors due to demand of 1 million yen

(115 yen=1 Euro)

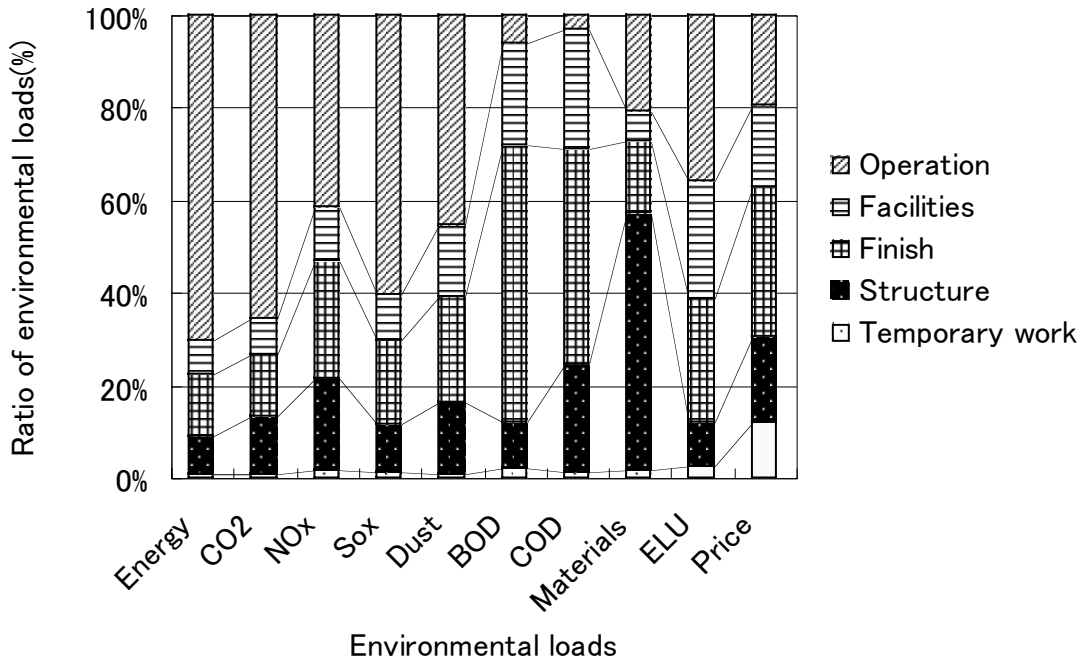
Industrial sector	Energy (MJ)	CO2 (kg-C)	NOx (kg)	SOx (kg)	Dust (kg)	BOD (kg)	COD (kg)	SS (kg)	Quantity of Mat.
Gravel	51251	962	29.6	8.1	0.42	2.7	2.5	2.1	392.3 t
Timber	17499	328	4.6	1.5	0.29	1.9	2.3	1.3	-
Plywood	26655	504	6.0	2.6	0.49	9.1	8.4	6.5	-
Resins	142353	2701	9.2	6.2	0.71	83.1	101.9	37.4	2.56 t
Paints	85296	1629	9.3	6.0	0.69	20.9	29.2	11.7	-
Gasoline	350289	6429							8.9 kl
Kerosene	1055105	19539	7.8	3.5	0.19	1.8	1.6	1.0	27.6 kl
Light oil	527597	9884	* Values in this box are only for the						13.0 kl
LPG	716606	11765	process						13.7 kg
Industrial sector	Energy (MJ)	CO2 (kg-C)	NOx (kg)	SOx (kg)	Dust (kg)	BOD (kg)	COD (kg)	SS (kg)	Quantity of Mat.
Coal	2482548	58637	10.3	5.4	0.36	3.3	8.4	2.5	71.1 t
Plastic	74698	1410	5.4	3.5	0.35	27.4	32.3	12.6	-
Rubber	52711	1014	5.7	3.5	0.29	11.3	12.6	6.3	-
Glass	61330	1177	18.6	5.6	0.98	5.8	7.5	43.1	-
G. fiber	69257	1285	18.5	6.0	1.0	29.0	18.4	15.4	-
Cement	347080	15989	32.3	9.5	0.8	8.0	3.7	7.8	94.6 t
Concrete	89370	3259	27.7	7.5	0.94	4.7	3.0	26.4	54.3 m^3
Pottery	36327	671	15.3	4.8	0.87	8.9	6.7	31.1	-
Steel	172870	3914	14.0	7.8	1.3	16.6	119.4	73.9	18.5 t
S. tube	119941	2674	14.3	7.9	1.4	10.1	60.7	38.0	6.69 t
Cast iron	170558	3811	12.1	6.0	0.92	4.8	13.9	16.7	4.14 t
Copper	21613	446	2.8	2.1	0.23	1.1	1.2	1.2	3.00 t
Aluminum	22425	443	2.9	2.1	0.22	1.5	1.4	3.1	4.44 t
Cables	35957	686	4.7	4.1	0.47	9.0	9.0	4.9	-

Cooking apparatus	37167	764	5.2	2.8	0.38	9.5	20.1	16.1	-
Refrigerator	24353	484	3.6	2.0	0.25	5.9	8.0	8.2	-
Pumps	29496	607	4.2	2.2	0.32	4.4	9.9	9.1	-
Construction machine	28013	569	3.9	2.1	0.28	5.0	10.6	8.8	-
Computer	14283	270	2.1	1.1	0.12	6.4	4.4	4.0	-
Lighting apparatus	27038	520	3.8	2.1	0.27	8.3	10.2	8.3	-
Wooden Houses	22353	463	4.3	1.7	0.25	6.9	7.0	8.2	-
Non-wooden houses	30654	668	5.2	2.0	0.28	6.4	9.8	11.4	-
Non-wooden Non-resident	31463	685	5.0	2.0	0.26	5.3	9.1	10.6	-
Electricity	322793	6046	17.2	15.4	1.1	2.0	1.6	1.4	47.6MWh
Water	34564	653	3.3	2.3	0.2	4.3	4.0	4.0	-
Road transport	55550	1042	26.9	6.8	0.06	2.3	1.6	1.3	-

Table 4. ELU (Reference 1.)

Category	Impact category	Unit	ELU(ELU/unit)
Disease on health	YOLL(Year of Lost Life)	Person X year	85,000
	Severe morbidity		100,000
	Morbidity		10,000
	Severe nuisance		10,000
	Nuisance		100
Depletion of resources	Fossil oil	kg	0.506
	Fossil coal		0.0498
	Natural gas		1.1
	Aluminum		0.439
	Steel		0.961
	Copper		208
Loads of atmosphere	CO2	kg	0.108
	NOx		2.13
	SOx		3.27

Figure 1. Ratio of environmental loads



Sustainable Comfort for retrofitting educational buildings

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1. INTRODUCTION

For historical and demographic reasons, in many European countries, an important part of educational buildings must be retrofitted in the next years. These retrofitting must be carried out in a context of reduction of greenhouse gas emissions and energy consumption.
In this context, the group of annex 36 of the International Energy Agency aims at promoting, for educational buildings, efficient measurements of retrofitting on energy level. In the same time, in France, an approach named HQE (High Environmental Quality) is developed as a specific action answering to the demand for green building and for integration of sustainable building concepts. In this way, the Rhône-Alpes authority leads actions for retrofitting educational buildings.
Among different targets for retrofitting, there are the improvement of comfort. Indeed, high and sustainable performances of indoor environment must be achieved with reducing energy consumption.
In this paper, special aspects of retrofitting educational buildings are set out, and comfort requirements are presented. Then, an assessment of comfort, in a study case, is exposed in order to present several sustainable comfort issues and decision makers constraints.

2. SPECIAL ASPECTS OF RETROFITTING EDUCATIONAL BUILDINGS

Because educational buildings are complicated structures, retrofitting design covers a broad and diverse range of activities and choices. Having a care for energy and environment questions in retrofitting does not mean buying and installing the latest or the most expensive equipment. Rather, it is a design philosophy that is focused on choices that improve the learning environment and save resources. Some choices stay essential.
Actually, educational buildings have many special aspects which should be considered in the design of retrofitting plans, hereafter some of these aspects are given:

- Educational building category includes different types: elementary school, high school, college or university, vocational school, kindergarten, training centres, etc.
- Educational buildings have different age, size, volume and can contain various space types with different set-point temperatures and activities. For instance, one of these may have intermittent heating, including: classrooms, libraries, offices, laboratories, dormitories, health care facilities, athletic facilities, auditoriums and others. This diversity of floor use creates both challenges and opportunities for implementing energy retrofitting projects of varying size and scope.
- A large diversity of material, construction (structure, facade, glazed wall, insulation, etc.), heating, ventilation and air conditioning systems, or solar and lighting systems, creates various issues which are strains on maintenance staffs.

- As educational buildings add space, the operation and maintenance of each addition is often different.
- Educational buildings sometimes use rooms, portable classrooms, or buildings which were not originally designed to service the unique requirements of educational buildings.
- Occupants are close together having four times as many occupants as office buildings for the same amount of floor space.

At the opposite of a new building, an existing educational building already have geographical constraints (site, orientation, etc.) and a technical, economical, social, environmental and architectural history which gives a framework for retrofitting.
For these numerous reasons, a broad and complete diagnosis of existing educational building is necessary before the retrofitting conception.

3. COMFORT REQUIREMENTS IN EDUCATIONAL BUILDINGS

Studies have indicated a correlation between the way educational buildings are designed, or retrofitted, and student performance. Studies were complicated by the highly systemic nature of education and the range of social, pedagogical and environmental variables involved. In fact, the educational process is strongly influenced by thermal, visual and acoustical comfort [High Performance Schools (c), 2001].

3.1. Thermal comfort

Thermal comfort is an important variable in student and teacher performance. Hot, stuffy rooms-and cold, draughty ones-reduce attention spans and limit productivity. They also waste energy, adding unnecessary cost to the energy bills.
Excessively high humidity levels can also contribute to mould. Thermal comfort is primarily a function of the temperature and relative humidity in a room, but air speed and the temperature surrounding surfaces also affect it [High Performance Schools (a), 2001].
Thermal comfort is strongly influenced by how a specific room is designed and by how effectively the Heating Ventilation Air Conditioning system can meet the specific needs of that room.

3.2. Visual comfort

Visual comfort means that lighting quality makes easier the visual tasks, such as reading and following classroom presentations. Students spend much of their day engaged in visual tasks-writing, reading printed material, reading from visual display terminals, or reading from blackboards, whiteboards and overheads. They must constantly adjust their vision from ‘heads up’ to ‘heads down’ position and back again. Inadequate lighting and/or glare can seriously affect a student’s ability to learn. On the other hand, a comfortable, productive visual environment will enhance the learning experience for both students and teachers [High Performance Schools (a), 2001].
Visual comfort results from a well designed, well integrated combination of natural and artificial lighting. Any strategy for enhancing the visual environment will therefore strongly affect the size and configuration of both these systems (for example type of windows, number, type and placement of light fixtures, etc.).

3.3. Acoustic comfort

Acoustic comfort means teachers and students can hear one another. When noise levels in the classroom are too high, students and teachers lose the ability to intelligibly understand each other. Typical sources are outdoor sounds (from vehicles and airplanes, for example), hallways (foot traffic and conversation), other classrooms (amplified sound systems and inadequate sound transmission loss), mechanical equipment (compressors, boilers and

ventilation systems), and even noise from inside the classroom itself (reverberation) [High Performance Schools (a), 2001].
Thus, acoustic comfort takes into account created sound barriers between classrooms and exterior sources of noise, mechanical rooms or equipment, noisy spaces within school, incorporated vibration isolators. It will reduce equipment noise and selected interior finishes which limit sound reverberation [Sustainable Schools Guidelines, 2001] .

Parameters	Regulations or recommendations
Temperature Winter/Summer	19°C<T<26°C (AICVF)
Relative Humidity	35%<HR<70% (AICVF)
Concentration CO_2	1000 ppm (OMS)
Illuminance tables	325 lux (AFE)
Illuminance blackboard	425 lux (AFE)
Noise	max 50/55 dB (A)

Table 1 Some comfort requirements for a classroom

3.4. Other aspects of comfort

In numerous countries, various recommendations about comfort parameters are proposed. A physical approach is given with numerical values defined with energy and environment considerations.
The interactions between thermal, visual and acoustic comfort, and even indoor air quality (ventilation), complicate the identification of a global comfort. For instance, if classrooms are cold in winter, or if the building is located, unprotected, on a noisy street or noisy HVAC systems, students and teachers will certainly perform as well. If unshaded windows create solar overheating, glare, or poor lighting results in eye strain, both students and teachers will be distracted. Students in classrooms that are quiet, well-lit, well isolated acoustically and properly ventilated will learn faster because they are more comfortable, can see and hear better, and are less distracted.
Moreover, in each existing educational building, it is possible to know occupants and experiment of maintenance staffs. Their physical and psychological appreciation about existing comfort, and also about structural and functional issues, let decision makers know their wishes and needs to define a retrofitting operation.

4. A STUDY CASE

4.1. Brief project description

One example of educational building, studied in the Region Rhône-Alpes, and integrated in case studies of annex 36 of IEA, is presented as an illustration (figures 1 & 2). The retrofitting project aimed to enlarge the built area and to retrofit spaces. The point is to unify teaching areas, to refurbish the general aspect of the building, and to correct comfort conditions. The final total floor area is 9000 m², with 600 pupils.
The oil furnace is replaced by a heat exchanger on the district heating service. Hot water is distributed to the rooms at a variable temperature depending on parts of the building. Ducts are insulated with 3 cm glasswool. Radiators with thermostatic valves contribute to the heat diffusion at a controlled temperature in the main part of the building. Domestic hot water is also produced by the heat exchanger through a interim storage.
For general classrooms, a minimum ventilation flow is provided by a mechanical ventilation. Additional needs are covered by a manual opening of the windows. Air inlets are located in the upper part of the windows and air outlets at the opposite wall. Fans running is temporised according to the occupation hours.

A Building Energy Management System is installed to manage heating, ventilation, alarms and maintenance.





Louise Labé secondary school is located near Lyon, built in the 1953 and retrofitted in 2000.
Figure 1: before refurbishment Figure 2: after refurbishment

Natural lighting is largely provided through highly glazed facade (ratio glazings/facade=0.79). Windows are equipped with roller blinds (ground floor) or outdoor screens (first floor) and horizontal solar protection as aluminium fins are installed on east, west and south facades. A zenithal lighting is provided in the workrooms of first floor by light-shelves.
In the classrooms, ceiling mounted luminaires with fluorescent tubes as blackboard lighting. In other rooms and corridors, ceiling inserted spots with fluocompact lamps, distributed on the corridors with time switches by the Building Management System.
Energy saving was not the main issue of this project but energy conservation for space heating should be achieved with a better insulation of the envelope and a better daylight in rooms.

4.2. Comfort assessment

People satisfaction regarding the comfort of the refurbished building was studied with an enquiry with provided questionnaires. The surveyed sample included teachers and students. Analysis of answers shows that:

- The results revealed some problems of low/high temperature linked to the control of the heating system. Level of temperature is good for 30% people, and acceptable for added 40%. Overheating problems are announced by 80% people in the afternoon and 50% in the morning, and 80% people have coolness feeling in the morning.
- Overall satisfaction noted about lighting, less than 30% have quoted sometimes a problem of insufficient lighting of blackboards or annoying glare.
- No problem were reported about the equipment, except some dissatisfaction relative to noise insulation between rooms or between rooms and circulation.
- Students complain about insufficient ventilation: sensation of enclosed space for 70% people, 80% feeling dusty and strong smell sometimes for 50% people.

Regarding the temperature recordings, made between the 13th and 20th March 2001, the set point temperature as designed are not fulfilled, especially set-back temperature is too high in the classrooms and the circulation.
A reduction of energy bill is achieved but the building management system is not efficiency used by maintenance staff who has not received a specific training on the energy and thermal management.
This study case gives an example of complex comfort constraints for the retrofitting educational building. Reaching a best level of comfort needs to control various parameters of the indoor environment.

Thus, if energy savings are carried out, a high level of comfort is not achieved. In 2001, others comfort studies in educational buildings of Rhône Alpes have shown this distinction between an energy consumption target and a comfort target.

5. SUSTAINABLE COMFORT CONSTRAINTS

In this study case, comfort requirements and results for retrofitting educational buildings can be defined by numerous parameters. Mainly, they give a numerical level of performance (temperature in wintertime and summertime, asymmetric radiation, surface temperature of floor, ventilation rates, illuminance, reverberation time, indoor air quality, etc.). These values are often numerical and static, but comfort cannot be considered as a static target for retrofitting educational buildings.

If sustainable concepts are integrated in a retrofitting educational building, comfort has to be the higher and the better for the lifecycle of building. So, time and dynamic parameters must be integrated in the comfort target.

Several factors must be taking into account. The historical life of the existing building shows a various comfort during the lifecycle of building. The comfort requirements and recommendations, and the indoor perception, are not the same originally and some decades later. The ageing of building and components exist, and population of occupants also move.

Physical and psychological factors for each occupants, teachers, pupils or students, are not static. For instance, activities and clothes influence the comfort perception. Even if specific indicators are developed, like the PMV (Percentage Mean Value), it is always difficult to integrate the own physical or psychological adaptation of an occupant in its thermal, visual and acoustic environment. The comfort for occupants integrates dynamic parameters.

Moreover, climatic conditions have impacts on buildings and occupants behaviour. Natural cycles (day and night, seasons, etc.) are sources of dynamic environmental constraints. Occupants stay sensitive to their natural environment and do not accept to live in artificial environment for a long time.

In fact, when the decision makers have to define sustainable comfort, they have to take into account different important choices:

- to propose a retrofitting project with a high level of educational conditions
- to reduce energy consumption for reducing exploitation cost of building (for example, minus 20%)
- to have the higher level of comfort (wintertime, summertime)
- to have a sustainable building and so a sustainable comfort.

Several interactions between possible choices exist and each target depends on the other. The result of retrofitting are linked by level of performance of each target (figure 3).

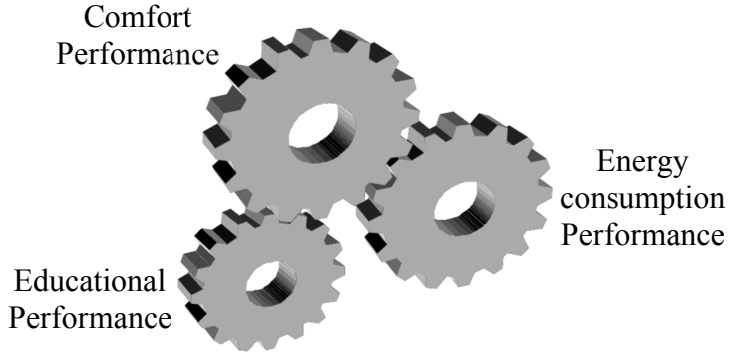

Figure 3 Interactions between performance targets

Thus, designers and engineers have to consider qualitative and quantitative, static and dynamic comfort targets for retrofitting. Their actions have to achieve the higher level of

comfort for answering to the needs of future occupants. But these choices are complex to make because of opposite constraints:

- What is the best combination between thermal, visual and acoustic constraints?
- Is the higher level of comfort, the lower energy consumption?
- Does a limited financial budget for retrofitting allow to integrate an efficient maintenance management system?
- Does existing building allow to propose satisfied and sustainable comfort solutions?

A strong opposition between the high level of comfort and the low energy consumption is not necessarily in favour of sustainable comfort. The challenge for decision makers is to find a balance between these different requirements.

6. CONCLUSION

Poor thermal, lighting and acoustic quality can become barriers to education. Retrofitting educational buildings must remove these barriers, allowing teachers and students to work in the best possible conditions. In this way, stakes about a large retrofitting education buildings stock overtakes aim of reduction of energy consumption. A high level of comfort is not necessarily sustainable comfort.

Even if this reduction of consumption allows decision makers to limit the financial costs of exploitation, sustainable comfort needs to take into account occupants and the lifecycle of building.

The choices for decision makers are complex. They need to deal with global and interactive approach in order to integrate occupants perceptions and behaviour. To reach the best indoor environment quality building, equipment and occupants have to be considered.

Quantitative and static assessment of comfort, as explained in high environmental quality, have to be associated to qualitative and dynamic constraints integrating physical and psychological perception of indoor environment.

In this way, a reduction of comfort cannot be synonym of a reduction of greenhouse gas emission. Thus, a sustainable comfort could deal with relevant aims of energy consumption management during all the lifecycle of building.

7. ACKNOWLEDGEMENT

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Community based sustainable and organic food crop production, in the UK, a solution for the 21st century

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ABSTRACT
This paper illustrates the growing demand for organic food-crops in Europe, particularly in the UK, and the issues, which prevent the introduction of large-scale organic food-crop production. The production of food-crops following sustainable principles and organic methodologies, from a new sustainable community is discussed as one solution to the growing need for organic food-crops. The problems preventing the expansion of existing and new non-organic food crop production farms are evaluated, including soil erosion, pollution caused by the production and transportation of agro-chemicals, employment, and water pollution. The production of food-crops following sustainable principles and organic methodologies, as part of an existing community is introduced as one solution to the growing need for organic food crops in the UK, and Europe. This latter solution is part of current research project at the University of Glamorgan. Development professionals, and academics who are involved in the expansion, or creation of existing communities will find this paper useful, in evaluating how land can, and should be set aside for the production of food-crops, following sustainable principles, and organic methodologies.

1. INTRODUCTION

Between 2000 and 2001 the sale of organic produce in Europe has increased by 50% with Britain having the fastest growing organic market within Europe for 2001, accounting for one per cent of the total value of food and drink consumed in the UK (Coghlan et al 2002, Soil Association 2001). However, of major concern is that only 25% of organic produce bought in the UK is grown within the country itself (Coghlan et al 2002). Alone, the pollution caused by transporting 75% of Britain's organic produce from global destinations to Britain, out weighs any environmental advantages of choosing organic produce. For example, 2.5% of Britain's total carbon dioxide emissions (CO2) is attributable to importing food and drink (Pretty 2002).

Perhaps, an immediate solution would be to adopt large-scale production of organic food-crops, in the UK and Europe. Logistically this would prove impractical as land rotation which alternate soil-building crops one year, such as pasture grasses, with food crops the next would be a prerequisite (Coghlan et al 2002). To meet current food crop production levels by non-organic farming methods would require twice the area of land used by non-organic methods,

with a catastrophic loss of natural habitats (Coghlan et al 2002). Equally there would be significant problems of environmental pollution, such as those caused by transporting food-crops to consumers, and the potential excess nitrogen from organic manure to pollute water courses (Coghlan et al 2002).

One proposed solution to meet Britain and Europe's needs for organic produce, and at the same time promote the use of sustainable organic principles and methodologies would be to promote local community-level based food-crop production. Indeed, there are many advantages of community food-crop production, including reduction of waste through recycling and composting, a reduction in traffic with its associated pollution, preservation of soils, and efficient use of irrigated water, and the provision of employment. All these latter advantages are significantly impacted upon using convention agro-chemical production (Smit 2002). One example of the viability of a local-level community, which is self-sufficient on locally produced organic food-crops, is the Bioregional development, at Beddington Zero Energy Development (BedZed), in south London, UK (Bioregional 2002). BedZed, consists of a sustainable community of 82 energy efficient flats and houses, which have used reclaimed materials or low embodied energy material in their construction (Bioregional 2002). The philosophy of BedZed is to reduce the ecological footprint of community living in the 21st century, which includes reducing CO_2 emissions from housing, using locally produced organic food-crops, adopting green transport, and the recycling all waste (Bioregional 2002). In addition, the BedZed project incorporates 2500 m^2 of workspace, to reduce the need for travel to places of employment (Bioregional 2002).

However, whilst the above provides a blueprint for sustainability, organic food-crops still represent a small proportion of food-crop production in the UK and Europe (Pretty 2002). There is a need to define some of the key issues relating to the environmental impact of continuing and expanding the existing large-scale non-organic food-crop production in the UK, and Europe if the argument for sustainability is to be understood.

2. KEY ISSUES RELATING TO NON-ORGANIC PRODUCTION OF FOOD-CROPS IN THE UK

Non-organic crop production is associated with many significant environmentally damaging problems, which are often be hidden to both the producer and the consumer of its products. The main problems of non-organic methodology are, soil erosion, and damage to the ecosystem through the manufacture and distribution of agro-chemicals, and the transport of food-crops to consumers (Coghlan et al 2002).

2.1 Soil erosion

The total land area of the UK (excluding Northern Ireland) is 229,334.00 square kilometres (km^2), of which 172,000.05 km^2 is in agricultural use (National Statistics 2001). In 2000, the UK Register of Organic Food Standards, (UKROFS), stated that 329,058.00 Hectares (Hs) of farmed land, was designated organic agriculture land, with a further 143,457.00 Hs of farmed land under conversion to organic agriculture land (Lamkin et al 2001). Thus, in 2000, the total farmed organic agriculture land, was 472,510.00 Hs, or 4,725 km^2 (Lamkin et al 2001]. Similarly, the Soil Association's Organic Food and Farming Report for 2001, estimates that the area of fully organic agriculture land in the UK, for 2001, had grown to 552,500 Hs, or 5,525 km^2 (Soil Association 2001). Therefore, it can be stated that organically managed agriculture land in the UK accounts for 3.2% of the total agricultural land (Soil Association 2001).

Significantly, up to 97%, or approximately, 167,275 km^2 (16,727,500 Hs) of land, is under intensive, or semi-intensive non-organic agricultural use in the UK, which is subjected to the application of synthetic pesticides, herbicides and fertilisers (agro-chemicals). Principally, the application of these chemicals is to promote the rapid growth and increased yields for crops, typically grown within mono-culture systems. The total tonnage of active pesticide ingredient (which includes herbicides, fungicides, insecticides, seed treatment, molluscicides, growth regulators and others) sold to all agricultural sectors in the UK, in 2000 was recorded as 23,650.00 tonnes (Crop Protection Association 2001). Of this tonnage 8,231.20 tonnes was used directly on agricultural land (Crop Protection Association 2001). This equates to an average application of 9.17 tonnes of active pesticide ingredient, per Hectare (H), over the 16,727,50 H of agricultural land designated as being in general agricultural use, within the UK. In addition, in 2000, the application of chemical fertilisers per H, totalled 8.60 tonnes [British Survey of Fertiliser Practice 2000].

It is known that the application of agro-chemicals is a primary cause of soil erosion with a resultant breakdown of soil humus and loss of soil fertility (Selincourt 1997). In Southern England, annual soil erosion losses of between two and 40.00 tonnes per H, have been measured (Selincourt 1997). A measurable loss of crop production is associated with soil erosion, for example, Douthwaite (1996) states that a loss of 12.00 tonnes of soil humus per year reduces crop yield by 8%. This is particularly disconcerting as it takes from 100 to 2,500 years to create 25 mm of fertile soil, and human interference, mainly through the application agro-chemical can destroy 25 mm of fertile soil in less than a decade (Rivers 1988). It is estimated, that on a world-wide basis, the application of agro-chemicals is eroding fertile topsoil at the rate of 25 billion tonnes annually; equivalent to seven percent of the world's soil every decade (Rivers 1988). In the U.S.A, it was predicted by Rivers (1988) that by 2038 the grain harvest would drop by between 50 to 75 million tonnes through the loss of fertile topsoil, over a third of the agriculture land, used for crops production.

2.2 Pollution from the production of agro-chemicals

Unlike, natural organic pest control methods e.g. partner allelopathy, or companion planting and natural organic fertilisers (manure from horses, cattle, and or chickens, fed on non-chemical based products) the production of synthetic pesticides and fertilisers consumes energy. As with all other industries, the use of energy (unless from renewable sources) results in emissions of the five known greenhouse gases, including carbon dioxide (CO_2), and thereby their production directly contributes to global climate change. The majority of synthetic pesticides are manufactured from intermediates derived from ethylene, propylene, or methane (Helsel 1987), which are transformed into the final products by a series of energy demanding chemical reactions involving heating, distilling, filtering and drying (Helsel 1987). In addition to greenhouse gas emissions caused by the manufacture agro-chemicals, their transport from the place of manufacture through the point of sale, to their application on the land are also hidden contributions to the overall greenhouse gas emissions, notably CO_2.

2.3 The hidden cost of pollution from the transport of agro-chemicals

After manufacture, agro-chemicals are packed into suitable containers, and transported to distributors, and ultimately to users for application to crops (Isherwood. 2000). In the UK, 80% of all fertilisers are typically delivered in 500kg bulk containers, with the rest delivered in 50kg bags (Isherwood. 2000). All fertilisers traded in the UK are transported by road (Isherwood. 2000) with 'distributor's vehicles, each travelling between 30 to 40 thousand miles a year, to reduce the need for on-farm storage as a result of stringent health and safety requirements. Typically, two drivers work from each depot, delivering to approximately 200

distributor member stores across Britain (British Agro-chemicals Association 2000). Logistically, this equates to between 12 and 16 million miles of road-based transport annually, contributing significantly to vehicle pollution, which according to Simms (2000), accounts for 80 % of CO_2 from transport, annually, in the UK.

2.4 Employment

In 2000, in the UK, only 7059 people were employed by pesticide manufacturing member companies of the Crop Protection Association (Crop Protection Association 2001). This figure includes 1633 people employed within distributor companies (Crop Protection Association 2001). It can be argued that the loss of employment from the demise of the UK pesticide manufacturing, and distribution, would be negligible and perhaps even advantageous; initially to the health of the redundant workers, and ultimately to the environment. Lampkin (2001) points out that historically, organic farm survey data indicates that overall labour requirements are typically 10-30% higher on organic farms, in comparison to non-organic farms. The agricultural labour force, for the UK, in all farming operations during 1999 was 593,000 (National Statistics 2001) and is in continuous decline. Potentially, it is possible that the change to organic agriculture could provide, between 59,000 and 177,000 extra employment opportunities, more than compensating for the loss of jobs in pesticide manufacturing and distribution, while also addressing in part, the socio-eco-political issue of reversing rural de-population.

2.5 Water pollution from the production and application of agro-chemicals

The residue from the application of chemical fertilisers and pesticides to land is leached into streams, lakes, rivers and aquifers to the detriment of diverse ecosystems, affecting human and animal health (Brenman 1999). Ecosystem damage is mainly caused by herbicidal chemicals and nitrogen from fertilisers, both of which are harmful to aquatic life, as well as being implicated in contributing to cancer in humans (Coghlan et al 2002). Economically, cleaning pesticides from drinking water costs £120 million annually in the UK, and the removal of nitrate £16 million. Whilst dealing with the problems of leached phosphate from fertilisers mixed with soil incurs a £55 million clear up cost. Overall, it was calculated in 1996 that a total of £2,343 million is spent annually, clearing up pollution from agro-chemicals from British watercourses (Pretty et al 2000).

Chemical companies introduce hundreds of new synthetic chemicals on to the market annually; much quicker than toxicologists and regulatory bodies are able to develop new methods, in which to detect them (Bengtsson, cited in Colborn et al 1996). In addition, Bengtsson (Colborn et al 1996), the head of the Swedish Environmental Protection Board's Laboratory for Aquatic Toxicology reported, in 1994, that toxicologists were falling behind in their ability to analyse and identify the contamination they encountered in the environment.

It is clear from the above discussion, that the current system in the UK, and other developing countries within Europe, of intensive non-organic food production, processing, transportation and distribution, is clearly unsustainable, and potentially hazardous to the health of the population at large, and the economic future of the countries that practice these methods. There is an urgent need to redress the problems faced by current practices with a locally-based organic method of food production, processing and distribution in order to achieve improvements in both environmental and personal health and thereby ensuring a sustainable industry that is socially, economically and environmentally responsible. The BedZed scheme discussed above, is a good example of these principles in which locally produced organic food-crops are produced within a sustainable community. However, there are a limited

number of existing and planned sustainable communities in the UK, and therefore possibly, the best option to promote the use of locally produced food-crops would be from within existing communities, on a localised level.

3. SUSTAINABLE AND ORGANIC FOOD-CROP PRODUCTION WITHIN EXISTING COMMUNITIES

A current research programme at the University of Glamorgan is investigating the methodologies necessary to establish a community based sustainable and organic agricultural strategy for food-crop production. The primary aim of the research programme, is to test the validity of the theory of localisation, sustainable principles and organic methodologies, within Wales, by determining how members of an existing community can work as volunteers together, and produce organic food-crops on small plots of land, within walking distance of their homes. The research includes interviewing and collating data from an existing group of 10 small-scale, commercial food-crop producers located in South Wales, that follows sustainable principles and organic methodologies, selling their produce through a co-operative. Each of the commercial producers cultivate plots of land up to 0.5 Hs, and although they grow by organic methods due to the small-scale nature of their plots, they are at present unable to register as organic growers under the organic aid scheme (Soil Association 2002). Similar working methods, crops usage, formative structure and subsequent development, labour input, productivity and produce distribution methods will be tested on the community based project, on a small plot of land of 0.15 Hs, that has been provided by the local town council. In addition, the research project will analyse the social issues involved in establishing a community based organic food-crop project. Such issues include the transfer of intrinsic knowledge that is held by the mature members of an existing community to its younger members, thereby ensuring a long-term viability for the programme.

4. CONCLUSIONS

This paper has illustrated the growing demand for organic food-crops in Europe, particularly in the UK, and the issues, which prevent the introduction of large-scale organic food-crop production. The production of food-crops following sustainable principles and organic methodologies, as part of the BedZed sustainable community, in south London, is discussed as one solution to the growing need for organic food-crops. The problem of starting the large-scale production of organic food-crops is seen to be unsustainable, as the demand for land usage is unsustainable, and the associated problems of pollution are prohibitive. Likewise, the problems preventing the expansion of existing and new non-organic food crop production farms are evaluated, which include soil erosion, pollution caused by the production and transportation of agro-chemicals, employment, and water pollution. The production of food-crops following sustainable principles and organic methodologies, as part of an existing community is introduced as one solution to the growing need for organic food crops in the UK, and Europe. This latter methodology is a major component of a research project currently being undertaken by one of the author's, at the University of Glamorgan. Development professionals, and academics who are involved in the expansion, or creation of existing communities will find this paper useful, in evaluating how land within local communities can, and should be set aside for the production of food-crops, following sustainable principles, and organic methodologies.

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Public evaluation of two-storey earth sheltered houses for sustainable communities in Wales, UK

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ABSTRACT
This paper presents the results from a pilot study of potential user response, to a sustainable community of two-storey semi-detached earth sheltered houses (esh units), in the UK. A response rate of 42% resulted in data being collected in 2001, by postal questionnaire surveys from a Welsh social housing provider, considering developing esh units for its prospective tenants. The first part of the paper evaluates the design of the esh units, and its simulated thermal performance, used as an example of two-storey esh units suitable for sustainable housing communities in the UK. The remainder of the paper discusses the results of the study in terms of the characteristics of the respondents, their attitudes towards the design of the esh units, projected internal temperatures, and their overall attitudes towards earth sheltered living. The study found that the respondents to the questionnaire survey viewed living in a sustainable community of two-storey esh units as very favourable. This paper will prove useful to developers considering developing esh units for their tenants and prospective purchasers, in the UK and Europe.

1. INTRODUCTION

At the beginning of the 21st century there are many issues facing developers of residential units, in the UK, particularly as there has been a predicted need for just under four million, and 225 thousand new homes to be built in England and Wales, respectively by 2016 (DETR 1998a, Cavill 1999). The issues include increasing the current density of housing developments from 30 houses to 50 houses per hectare; curbing carbon dioxide emissions from water and space heating, yet still providing houses with comfortable internal temperatures; reducing the destruction of greenfield land; and building houses which allow the occupants to feel part of a community (DETR 1999). There is one exception to increasing housing densities, and that is where houses are designed with a sustainable ethos, and are part of a sustainable community (DETR 1998b). One answer to the housing need, which will address the above issues, is to develop sustainable communities of earth sheltered houses (esh units). This paper reports the findings of a pilot study of consumer attitudes within Wales, toward living in a two-storey earth sheltered house (esh unit), which could be built as part of a sustainable community in Wales.

2. EARTH SHELTERED HOUSING

Readers should not confuse esh units with underground houses, i.e. houses that are built below ground level, and rely on rooflights surmounted on their roofs for daylighting. Esh units are houses, which can be built into a sloping site, and have been built on flat sites. The most common form, and energy efficient esh unit type found in the UK is the exposed south wall type (ESWT), (Littlewood 1998, 2001). In the ESWT esh unit, earth from the excavation of the construction site is placed on top of the esh unit's roof. Earth is also abutted up to all the external walls (except that which faces within 30 degrees of south), and sloped at a minimum angle of 45 degrees, down to the existing ground level. Esh units have been developed around the world in a variety of designs from one to three storeys (Baggs 1991, Sterling 1981), with over 4 million in China, a few 100 in Australia, 10,000 in North America (Dineen 1987), and between 30 to 40 in the UK (Littlewood 2001). It is difficult to give a precise number of esh units within each country in Europe, since the authors have been unable to source a definitive study by academics or professionals, in comparison to America, Australia and the UK. However, during the 1970s, Sterling (1981) identified 40 single-storey esh units in Valbonne, France. Once developed, esh units are considered a relatively sustainable form of housing, and according to Baggs (1991), Sterling (1981), Carpenter (1994), Carmody (1985), White (1998), and Littlewood (2002a), this form of housing can reduce the need for active space heating, and its associated CO_2 emissions. However, space heating can only be eliminated if a number of features are used, which include building the house into an earth banking, which is well drained, and sheltering the roof and walls with earth of between 250 and 1500 mm thickness (from the external structure outwards), (Baggs 1991, Sterling 1981, Carpenter 1994, Carmody 1985). Other features include designing the house around passive solar design principles, which include orientating exposed high performance (1.5 W/m^2K) windows within 30 degrees of south, appropriately positioned super-insulation (0.2 to 0.13 W/m^2K), ventilation heat-recovery systems, inclusion of a passive sunspace, and using a massive structure, for thermal storage (IEA 1997, Winter 1998). Other advantages of esh units, include greater sound insulation than in a conventional heavy mass, or timber frame house (Baggs 1991). In addition, if the earth which shelters an esh unit, is planted with grass and indigenous plants, it will retain and re-introduce natural wildlife habitats, which in turn can process harmful CO_2 emissions through photosynthesis (Wells 1998, Littlewood 1998, 2001).

In the UK, and towards the end of the 20th century, esh units have been receiving greater attention from potential designers, developers and self-builders, as a result of the successful occupation and monitoring of five single-storey esh units, at Hockerton, in the North of the UK (BRECSU 2000). Typically, esh units have been constructed as single-storey houses in the UK and therefore cannot achieve medium density development. However, the esh unit included as part of the pilot study reviewed in this paper, was designed in a two-storey format, and therefore would use approximately 50% less land in it's footprint than a single storey esh unit, of the same useable floor area. Therefore, greater unit (or dwelling) densities could be achieved with two-storey esh units than with single storey esh units.

3. EXISTING RESEARCH

The greatest research undertaken into the design and development of esh units, originated from the USA, in partnership with the Underground Space Centre, Minnesota USA between 1975 and 1985 (Carmody 1993). The popularity of esh units in the USA, increased

dramatically from 1973 to 1985, as a direct result of the oil crisis (Sterling 1981). In 1973 there were only a few hundred esh units dotted around the USA, but by the end of 1975, there were a few thousand (Sterling 1981). To date the only research study undertaken in the UK to address the public's perception towards esh units was that by Littlewood in 1998, which was part of a PhD research programme, but was not published. Littlewood, targeted the perceptions of the public who had previously expressed an interest in living in an esh unit. The main aim of the study was to ascertain which design features incorporated into esh units, would be acceptable, and which design features may dissuade would be occupiers from renting or purchasing such housing.

In 2000, one of Wales' largest developers (discussed as market1, hereafter) and owners of affordable homes, expressed an interest in developing a series of esh units, based on research finding from Littlewood's (2001) PhD research programme. Therefore, a pilot study was undertaken in 2001, to establish whether there was a market for esh units in Wales, which included sending 50 questionnaire surveys to a selection of staff and tenants from market1.

4. EXPERIMENTAL HOUSE

Because esh units are a relatively unknown housing concept to the general public in the UK, an artist's impression and predicted temperature profile of the demonstration esh unit, designed by Littlewood (2001), was included with the 50 questionnaires sent to market1 (see Figure 1.1, and Figure 1.2. The esh units were designed as a pair of semi-detached dwellings, with three bedrooms, and on two-storeys, which is the UK's most common, and desired house type by both single and family purchasers (Nichol 1998, Hooper 1998, DETR 1998b). Each esh unit also included a garage, which is seen as a desirable feature in an UK house. The roof of the garage provides access to the private roof garden. The esh units do not include any form of active space heating, but rely on heat losses from occupants, lighting and other appliances. In addition, the esh units are designed following the passive solar design and earth sheltering principles discussed above in section 2. For more details on the design and thermal performance of the esh units refer to Littlewood (2001, 2002a).

5. FINDINGS

The response rate of 42% from market1, is deemed to be very good for postal questionnaires, as Fellows (1997) points out, the expected response rate is only 10%. It could be concluded that the high response rate indicates that the topic of developing and living in esh units is of general interest to potential tenants, owner-occupiers, and developers in Wales.

5.1 Characteristics of respondents

The gender of respondents were 52% women and 48% male, which contradicts Stuart's (1979) research, which dictated that the majority of visitors, and positive respondents to esh units in Carolina, USA were male. The majority of respondents were well-educated (77%), and in professional roles. The age distribution of respondents was in five groups, 22 to 25 (9%), 26 to 30 (9%), 31 to 40 (31%), 41 to 49 (20%) and 50 to 59 (31%). Over half (61%) of the respondents were aware of esh units, and knew the principles of earth sheltering, which is not surprising since market1 had followed the progress of Littlewood's (2001) research for a number of years.

5.2 Consumer attitudes towards alternative housing developments

The following responses were asked, as they are particular features of Littlewood's esh unit, but the respondents were not asked to relate their comments towards Littlewood's esh unit.

85% of respondents felt there was a need to develop houses, with a reduced visual impact, particularly in the countryside. The knowledge that CO_2 emissions are one of the main greenhouse gases attributable to housing in the UK, and which cause climate change, is probably why 100% of respondents wanted to live in a house which curbed these emissions. This latter finding is important, when 98% of respondents wanted to curb the need for active space and water heating, but required comfortable internal temperatures of between 18-23 C^o. Three bedrooms, as standard were favoured by 75% of respondents, and a house with plenty of private garden space by 80%. This latter point is particularly interesting since 85% of respondents felt that housing should be developed, which reduces the amount of land currently used, i.e. respondents believe housing densities should be increased. If housing densities increase, then garden sizes must be reduced. The advantage of esh units, over conventional housing in the UK, particularly Littlewood's esh unit, is that having no rear garden saves land, and the front garden could almost be removed. Yet, there is still a private garden of 60 m^2, on the roof, to meet the respondent's needs.

5.3 Consumer attitudes towards Littlewood's esh unit

In order to test whether the respondents had any pre-conceived attitudes towards living in an esh unit, they were asked to rate their impressions of the esh unit in Figure 1.1 and 1.2. Unobtrusive, innovative, appealing and aesthetically pleasing were the most popular impressions (91%) of Figure 1.1. However, the negative impressions of Figure 1.1, were that the respondents felt that it would be dark (9%), there would be a lack of view (9%), and a need for two exposed external walls (9%). However, these latter respondents would still consider living in an esh unit. Carmody (1985), also documented similar negative impressions towards esh units. Since only a small percentage of respondents had negative feelings towards the esh unit, an emphasis should be placed on changing people's misconceived ideas through demonstration projects.

5.4 Consumer attitudes towards a community of esh units

From the minor (9%) negative feedback in section 5.2 above, the majority (91%) of respondents would consider living in an esh unit, if it were situated in a rural (42%), urban (15%), suburban (19%), or inner city area (9%). It is pleasing to note that at the beginning of questionnaire, 39% of respondents were not aware of esh units. Yet, after reading through the questionnaire survey and the enclosed documentation (Figure 1.1 and 1.2), 31% of these 39% respondents would consider living in such a dwelling. There were a high percentage of respondents (91%) who would pay up to 5% more for an esh unit, if the utility bills and the visual impact of the dwelling were reduced. Ford (1998) predicts that earth sheltered buildings could cost up to 5% more than conventional buildings, in relation to their insulation requirements. Interestingly, for a developer of affordable homes, the respondents felt that esh units should be offered for sale (61%), shared equity between tenant and the developer (23%) and mixed tenures (38%). These three purchase/rental options have recently been successful at Bioregional's zero energy sustainable community (BedZed) in London, which consists of 82 houses and flats, completed in Spring 2002 (Bioregional 2002). Another feature of sustainable communities, which proved popular (42% yes, and 42% maybe) was for land to be included which could be used to produce organic food-crops. The production of organic food-crops at BedZed is documented at Bioregional (2002) and Littlewood (2002b). Most of the respondent wanted to live in a community of 11 to 20 units (42%), with 21 to 50 units and 6 to 10 units providing the same response (19%), 1 to 5 (9%). Only one respondent wished to live in a community of up to 100 esh units. Following the responsible attitude toward

increasing housing densities the majority of respondents felt that a mix of semi-detached and terraced esh units should be built in a sustainable community (66%).

5.5 The future of esh units in sustainable communities

It is surprising that after 91% of respondents suggested that they would live in an esh unit as part of a sustainable community, only 71% of respondents felt there was a future for this type of housing in Wales. Perhaps this is some indication of the difficulty there is in developing innovative houses in the UK, and particularly Wales. However, the overall response in the comments section on the questionnaire survey, was a need for at least one demonstration project, to be built in Wales, with a series of two-storey esh units, to test the practical application of living in such dwellings. A live demonstration project, which is lived in by real people, is one project which the authors of this paper are trying to establish in Wales. To date, such an idea has had the support of market1, and by the Chairman of the National Assembly for Wales' Sustainability and Energy Group.

6. CONCLUSIONS

A history of earth sheltered houses (esh units) which have been built around the world has been discussed, and it is seen that the Exposed South wall type, is the most energy efficient and common type of earth sheltered house (esh unit), in the UK. It is seen that esh units are becoming better known in the UK due to the completion and occupation of five such dwellings in the UK, in 2000. Most of the existing research into the public attitudes towards esh units was conducted in the USA between 1973 and 1985. This paper presents the first known survey in the UK, which addresses public attitudes towards living in an esh unit, as part of sustainable community. The findings of the survey, which had a 42% response rate, suggest that 91% of respondents would like to live in an esh unit, if it were one of twenty semi-detached, or terraced esh units with two-storeys, in a sustainable community, with mixed tenures, including rental, and purchase options. It is concluded that there is a need to build a demonstration project of two-storey esh units in Wales, to publicise the benefits of esh units, which the authors of this paper are currently working on, with a number of partners.

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Figure 1.1**: Artist's impression of Littlewood's pair two-storey esh units**

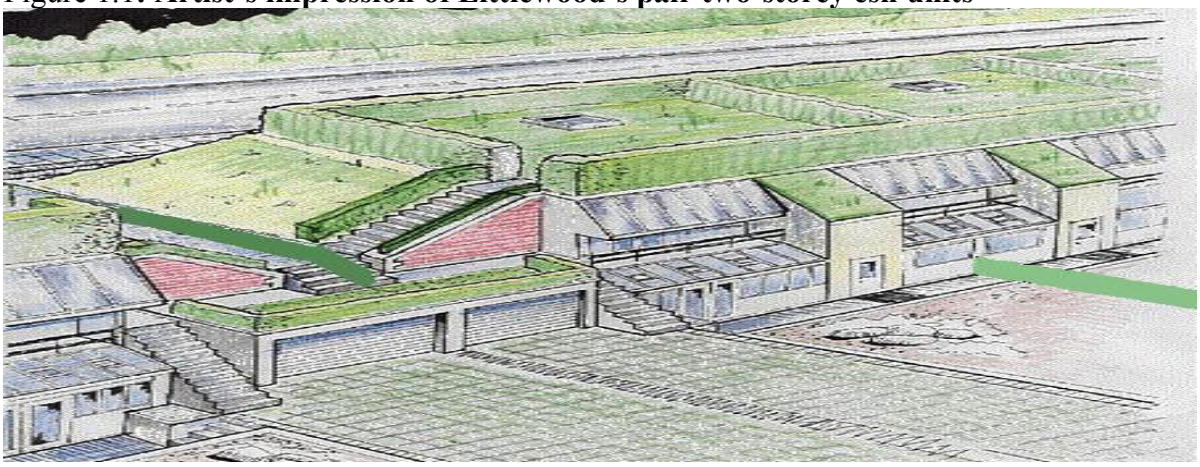
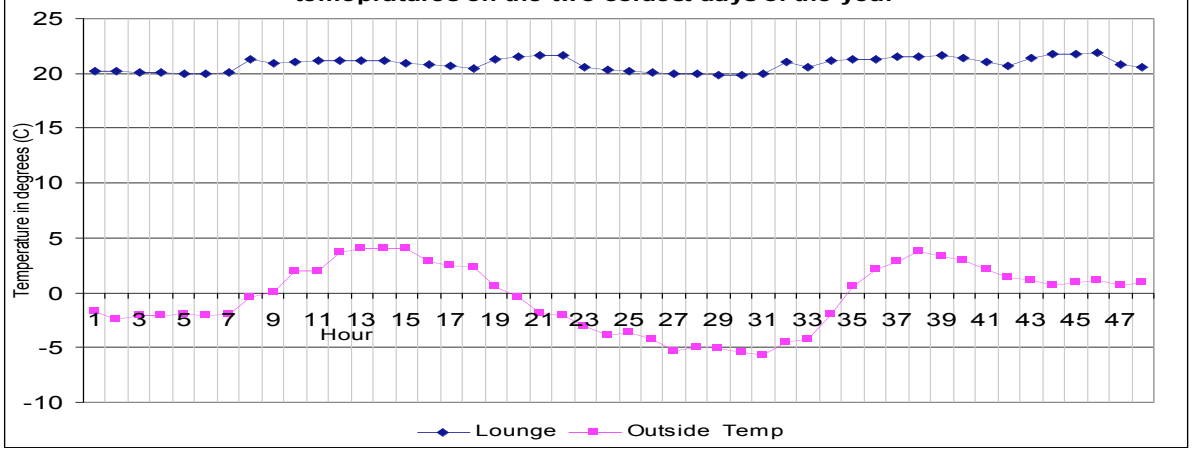


Figure 1.2: **Resultant temperature in the lounge compared with the eternal temepratures on the two coldest days of the year**



DPL: a tool for assessing a district on sustainability

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1. INTRODUCTION

Local governments in the Netherlands are developing policies to plan districts in a sustainable way. The elaboration of these policies is not a simple task. One of the reasons is the broad and confusing definition of sustainability. Within this broad definition there is a considerable chance for incompatible goals. Various parties use different interpretations for the concept of sustainability. For parties involved, such as local authorities and property developers, it is not easy to jointly formulate unambiguous goals for sustainable planning. The definition of sustainability for an urban plan can not afford to be unclear because it has to fight its way among a large set of other requirements.

In the last ten years initiatives started in the Netherlands to develop instruments for assessing sustainability on the level of districts. Examples of Dutch tools are: de Bestuurlijke Bandbreedte Methode (Utrecht), de Stads Stolpmethode (Amsterdam) and the Ecopolis Strategie (Nijmegen). However, the interpretation of sustainability in these instruments varies strongly. The Councils of Housing, Spatial Planning and the Environment concluded that due to the diversity and nature of the instruments it is insufficiently clear what is sustainability, who makes the choices about sustainability of a plan and based on what.

Against this background, the initiative 'Sustainability-Profile for Districts' (the Dutch acronym for Duurzaamheid Prestatie voor een Locatie is DPL) started in May 2000. The DPL initiative was initiated by a consortium of the Dutch Ministry of Housing, Spatial Planning and the Environment – Directorate General of Housing, IVAM Environmental Research, TNO – Building and Construction Research and TNO Environment, Energy and Process Innovation (J.G.M. Kortman et al., 2001).

2. AIM OF THE INITIATIVE

The initiative aims to develop and test a challenging tool for assessing sustainability at district-level. The target groups for the application of the tool are municipalities, project developers, citizens, business community's etc. The name of the tool is DPL. The tool assesses in a clear and transparent way the spatial plan for a district on sustainability, based on the information from the urban plan. It so helps urban designers to creatively improve the sustainable performance of a district.

The tool can be used in selected phases of an urban planning process. In the phase of definition the tool supports to formulate quantifiable objectives for sustainability as part of a total set of requirements. In the phase of design it helps to compare the different plan

alternatives and improves the urban plan. In the phase of evaluation the tool can be used to monitor a location and compare the sustainability performance of various districts in a town.

Until now, the initiative performed three steps:
1. Define and unravel the concept of sustainability for urban planning;
2. Develop a prototype instrument to asses a district on sustainability;
3. Test this prototype in three case studies.

The outcomes of these three steps are presented in the next paragraphs.

3. DEFINE AND UNRAVEL SUSTAINABILITY FOR URBAN PLANNING

In the Netherlands some first-generation instruments, such as the Bestuurlijke Bandbreedte Methode are already tested in practise. These outcomes of these Dutch instruments still vary considerably. The ambition of the DPL project is to make a next step and develop a second-generation instrument that sets a standard for the quantitatively determination of the sustainability performance of a district with a consistent set of criteria. For some criteria it appeared not yet possible to quantify the impacts. The tool therefore will allow to add qualitatively results for those criteria where quantification it not possible.

The instrument is build upon three axes (see Figure 1). The X-axe represents the concept of sustainability, the Y-axe represents the physical feature of a district and the Z-axe the planning process. In various phases of the planning process the instrument helps to determine the sustainability performance of a district from the physical features of the district.

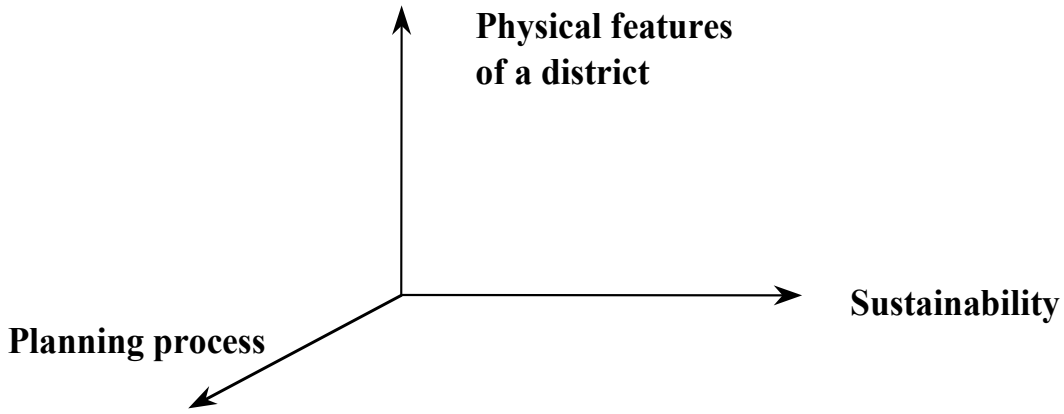

Figure 1 The 3 axes of the DPL instrument

Sustainability on the X-axe is interpreted as an integral concept, which is systematically divided into various levels of criteria, which are presented in the form of a pyramid. The top is presented by the overall concept of sustainability (see Figure 2). On the second level you find three elements which are closely connected to the three P's: environment (Planet), liveability (People) and economy (Profit).

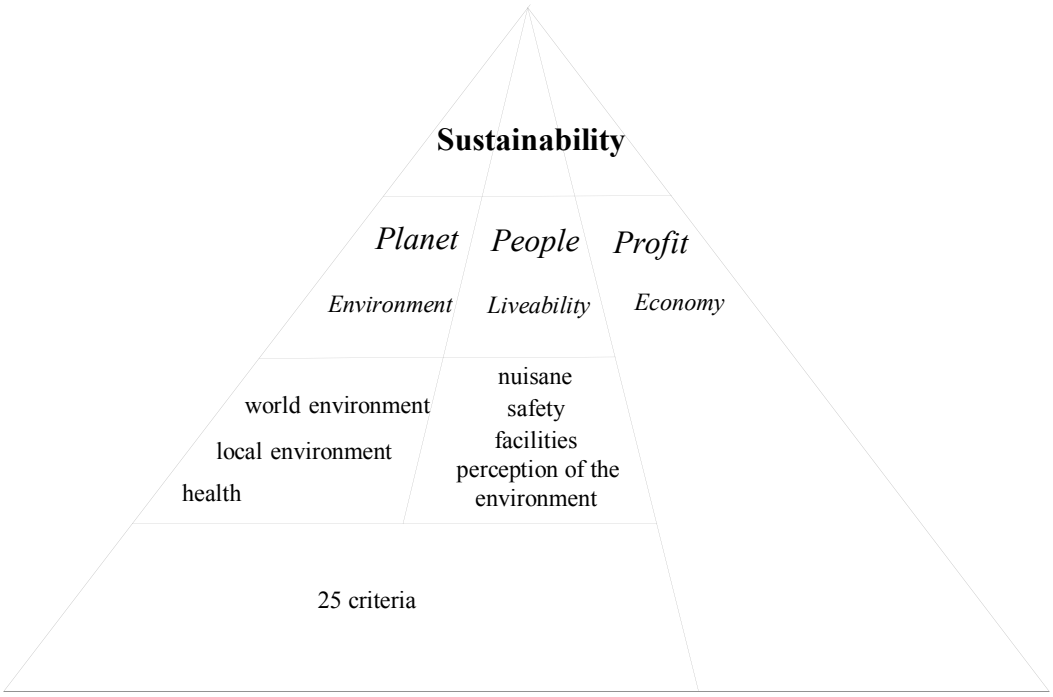

Figure 2 Pyramid for sustainability

On the second level the two elements, Environment and Liveability are unravelled in 7 themes (see Figure 2), followed by 25 criteria in the fourth level. These 25 criteria are selected for the prototype tool from a total of 200 criteria that were found in literature and currently existing tools. This selection is meant to be a first set towards a more complete and consistent set of criteria for sustainability. Each criterion is connected to an indicator. The DPL scores for each criterion are determined by translating information from the urban plan with a formula and data into a score for an indicator. The scores for these indicators are the outcome of the DPL tool.

4. DEVELOPING THE DPL TOOL

On the basis of this pyramid for sustainability a first DPL prototype tool was developed that assists planners to determine the sustainability performance of a district. It consists of three parts:

1. The DPL questionnaire;
2. The DPL matrix;
3. The DPL profile.

4.1 The DPL Questionnaire

The sustainability performance of a district is determined in the prototype on the basis of the physical characteristics of a neighbourhood. The necessary information of an existing neighbourhood or information from an urban plan is filled in the questionnaire. Examples of physical characteristics are the number and floor area of houses, offices, roads, the modal split and nuisance from noise, odour etc. This information is automatically transformed to the DPL matrix.

4.2 The DPL Matrix

The DPL matrix automatically transforms the information from the questionnaire into indicator scores by using the formula and the data. The DPL consists of two axes (see Figure 1). The Y-axe presents the various functions of a neighbourhood, such as houses, parks, offices, infrastructure, factories etc. The X-axe presents the 25 indicators for sustainability. Each box of the matrix consists of data and formula. For example for the indicator energy use of houses, data for energy consumption is connected to the m2 living space, which is filled in the questionnaire.

4.3 The DPL profile

With help of the matrix the DPL profile is calculated and related to the amount of ground surface of the district in question (see Figure 4). In this figure the DPL profile is limited to 8 indicators.

5. TESTING THE DPL TOOL IN THREE CASE STUDIES

In the first DPL project the practical value of the tool was tested in order to know if the instrument is suitable for the needs of the Dutch planning-practice. Therefore the tool was tested in three areas that are being reconstructed:

- Geuzenveld, Amsterdam (district with low and middle high rising buildings, which was firstly constructed after the second World War);
- Poptahof, Delft (district with low, middle and high rising buildings, which was firstly constructed in the sixties 2001);
- Transvaal, The Hague (district with middle high rising building, firstly constructed at the end of the 19th century).

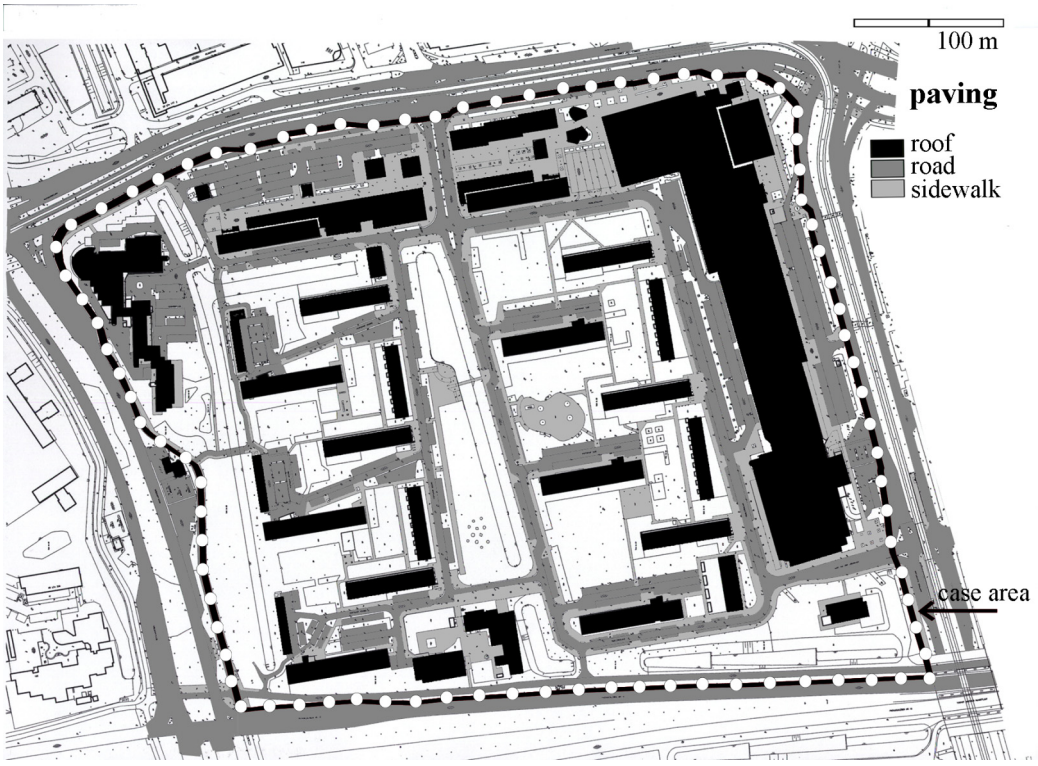

Figure 3 One of the case studies: Poptahof, Delft

The case studies were focused on the practical side and intrinsic value of the instrument: Is it manageable, conveniently arranged, quickly to apply; does it meet the needs of the parties; is there sufficient data available; is it sufficiently capable of mapping the actual practical value, perception and appreciation? The members from municipalities (Amsterdam and The Hague) and a research group from Delft collected the data from these neighbourhoods and transported these data into the questionnaires. Based on the (sometimes incomplete) set of data the sustainable profiles of the three neighbourhoods were calculated by IVAM with help of the DPL matrix. A part of the sustainable profile is presented in Figure 4. Because it was the first tryout there were not yet reference scores available for various types of districts in the DPL tool. The indicator scores for each of the three districts are compared to the average score (=100%) of the three neighbourhoods.

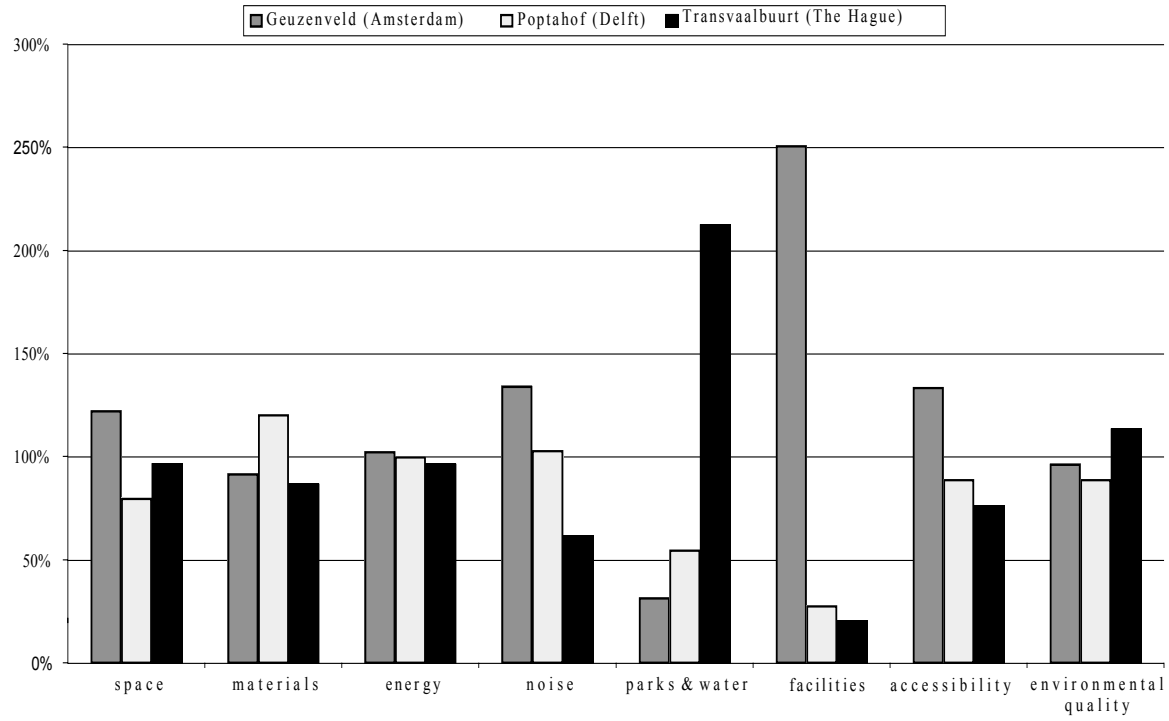

Figure 4 Comparing the DPL profiles of 3 districts

The lower the scores the better the performance of the district. The profile indicates that the district Poptahof in Delft has relatively good scores on the aspects of ‘space’ and ‘facilities’. The oldest district Transvaal in The Hague has relatively good scores on ‘space’, ‘materials’, ‘noise’, ‘facilities’ and ‘accessibility’. The district Buurt 9 in Amsterdam scores well on the criteria ‘parks’ and ‘water ‘. Comparing the three districts with various typologies has a limited value. Therefore the scores from the first three cases has to be treated very carefully because there are not yet good reference profiles for various types of districts.

6. PRELIMINARY CONCLUSIONS

Municipals were able to deliver about 75% of the necessary information. With help of the DPL prototype tool it was possible to determine (part of) the DPL profiles of the three districts. The comparison of the three cases can not be used to select the most sustainable district. The scores from the first three cases has to be treated very carefully, because there are not yet good reference profiles for various typologies of neighbourhoods. The comparison is only performed to test the usefulness of the instrument. Especially for the element of liveability necessary information is lacking. Additional information should be used in the case

of an existing neighbourhood from liveability research by questionnaires filled in by the inhabitants of a district.

Sustainable building on district level is still in its infancy. Local governments still lack a comprehensive view of how to improve districts in a sustainable way. The instrument DPL is a guide to find the most efficient improvements.

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Sustainable Building Design - The Universeum Case

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1. INTRODUCTION

This paper precedes a forthcoming licentiate thesis on requirements of importance for building design processes emphasising integration of global environmental aspects into a complex local design situation. In the thesis, this integration is discussed from a design theory perspective, using empirical data from a case study of the design process for the National Science Centre building "Universeum" in Göteborg, Sweden. The thesis is to be published in August 2002 (in Swedish, with an English summary). At an early stage, this research project was reported in two conference papers, Edén (2000) and Wallin (2000).

2. THE CASE

Universeum is designed to be a major educational institution as well as a tourist attraction. It was inaugurated in June 2001, a week before the EU Summit (and was part of the localities for Summit activities). The overall aim of the Universeum project is to awaken the interest of young people - and especially girls - in technology and natural sciences, thus encouraging them towards studies and professional lives within those fields. The pedagogical efforts emphasise the importance of an environmental perspective. The building itself is designed to symbolise and exemplify this.

The building is a thrilling architectural collage astride a highslope: It has a "traditional" hands-on science centre department in a modernistic wooden structure, a glass greenhouse with a tropical rain forest, a major ocean aquarium faced with rock material from the site, and a plastic-roofed "waterway" exposition of Swedish biotopes from the alps to the west coast. The commissioner for this large investment (some 40 Million Ecu) is a foundation with four interested parties: The Gothenburg Region Association of Local Authorities (GR), the University of Göteborg, Chalmers University of Technology and the West Sweden Chamber of Commerce and Industry. The institution is operated by the company Universeum AB (Ltd).

3. THE RESEARCH PROJECT

The research project evaluates efforts of environmental adjustment in the Universeum design process with the aim of summing up and discussing experiences of the process. In accordance with the explorative approach used in the study, an open research question was put forward: What factors are important in a sustainable building design process? "Factors" were undefined but exemplified, as prerequisites, competence, knowledge, tools, design operation etc. Methods used in the case study are mainly half-structured interviews and project document studies. To a minor extent, Participative Observation was used, mainly by attending design decision meetings and meetings with the reference group, and with the Universeum Environmental Advisory Board.

The research project is financed by Universeum AB.

4. THE UNIVERSEUM DESIGN PROCESS

4.1 Two Project Concepts Merge

The building programme constitutes two main concepts: a water-based bio-zoological exhibition and an experimental, hands-on technical exhibition. These Science Centre concepts were first separately developed - each promoted by an enthusiast - but later merged on the basis of a regional political initiative. Already in the two original concepts, environmental concern was part of the agenda.

4.2 Business Plan and Financing

As part of the financing, the proprietor elaborated a business plan, describing the ideas and stating the project goals. In this plan, environmental ambitions were expressed in symbolic terms. "The ecological perspective" was considered to be a key component in the pedagogical efforts. Environmental adjustment of the building was presented as a symbol and example of project activities supporting the pedagogical aims. Limiting the environmental load of the building itself was not the primary focus. The Swedish Government added approximately ECU 5 M to the financing by founders, industry and private and public foundations. Half of this sum was an explicit support to the environmental ambitions of the project, although in practice the entire sum was regarded as such.

4.3 Architectural Competition

As the first step of architectural design, an architectural competition was held, with seven competitors. The competition program contained an appendix titled "Sustainable Architecture". This appendix was written by a Chalmers instructor and researcher, an expert in Sustainable Building. The proprietor was not highly engaged in forming these environmental guidelines. The approval of the competition programme, including the guidelines, was the responsibility of the jury. In the assessment of the competition proposals, representatives of Chalmers School of Environmental Sciences (GMV) were engaged as experts to the jury. Three proposals - one of these the winning one - out of seven were seen as having great potential for developing environmental qualities.

4.4 Environmental Reference Group

Five researchers from GMV formed an environmental reference group to support the design. The group acted as advisors to the proprietor, without any consulting responsibility, and supported the proprietor in elaborating and securing the fulfilment of the environmental aims of the project. The need for help from this group was a consequence of the governmental financial support to environmental measurements, calling for supervision of adequate use of the money. In the group, the Sustainable Building expert from Chalmers was engaged as a co-ordinator, paid by the proprietor. Resources for the other researchers were to be supplied by the universities as part of their founder responsibility. This was not regulated, though, and the researchers complained about lack of time for their project participation.

4.5 Environmental Programme and Plan

Following a model worked out by parties of the Swedish building industry, *Miljöanpassad projektering* (*Environmentally Adjusted Design*; 1997; below EAD), an environmental programme was elaborated. The environmental co-ordinator was asked to write the programme. He wrote a tentative version, which was intended to be finished by the consultants, for two reasons: They were to learn by doing their own writing, and they were to take the responsibility that a researcher, who was not a member of the design team, could not take.

The draft, though, was not completed, but a plan for realising it in the design, building and operation processes was worked out by the architect. The programme was published at the end of the systems design and thus applied to the detail design, although it also mirrored system design discussions. The proprietor was not highly engaged in the work, and the project manager did not use the goals as guiding and controlling instruments.

4.6. Environmental Consultant and Environmental Design Meetings

At the end of the systems design phase, an environmental consultant was attached to the design group. This was not a result of the proprietor's choice, but of a need the other consultants had, especially the architect, for environmental investigation resources. The environmental consultant led special meetings on environmental design issues, or rather environmental aspects of design issues. This meant that such aspects were partly separated from ordinary design meetings, and thereby from the main design context.

4.7. Environmental Investigations

Some design issues were chosen for special environmental analysis, for example: 1) The framework of a roof was proposed by the architect to be an advanced gluelam construction, obviously symbolising environmentally-based technical development. The project manager wanted to investigate a cheaper steel construction. The investigation showed the environmental advantages of the gluelam alternative, which was chosen by the company board. It was the most expensive solution, but architectural arguments were given priority, with supportive environmental reasons. 2) Another roof was to be covered with glass. For cost reasons, multi-welled plastic sheets substituted for glass. An environmental study showed that the thermally insulating properties were similar for the two materials. 3) Stainless steel contra recycled aluminium frames for glass structures was investigated. As the environmental load was found to be equal, the cheaper aluminium alternative was chosen.

5. RESULTS

The case illustrates the well-known gaps between practice and research: 1) Practitioners seek immediate solutions as part of the design method, researchers advocate that the first step should be to identify systems requirements ; 2) Practitioners are in need of prompt design decisions even if knowledge is insufficient or uncertain, researchers are unwilling to support insufficiently knowledge-based decisions; 3) Practitioners are in need of specific knowledge based on the local design situation, researchers produce general knowledge that must be situationally interpreted and locally adapted to be useful in practice.

The Universeum design process is a clear example of a learning process. The actors gradually understood more about environmental design as the work progressed. Obviously this applies to the proprietor, who had no prior experience in the field. But it also applies to the design professionals, the project manager and the consultants. Many environmental design steps were made on virgin soil. The architect, however, treated environmental issues as a part of his design repertoire from a symbolic, architectonic point of view.

The study shows that environmental investigations were carried out selectively, in a few cases, mainly as one of several means of settling disputes over alternative solutions, by taking into account several aspects of design. The foundations for integration of environmental aspects into the project were established in the competition proposal, assessed by the environmental experts to the jury and not put in question after that.

The building resulting from this design process is a thrilling one. The environmental performance of it, not an object for this evaluation, is however still to be investigated. Every building is more or less a unique creation - Universeum definitely more so. Therefore, bench-marking in such an investigation will be a considerable problem.

6. DISCUSSION

6.1 Integration and Separation

Environmental aspects of the design process reflect the question of dialectic relation between *integration* and *separation*. Epistemologically, this is about the notions of *part* and *system*. From a design theory perspective, the focus on environmental aspects in design could be questioned as a reductionistic scientific view, when a system theory approach might seem more appropriate. A dialectic view would take into consideration the relation of environmental and other aspects of design in an interaction between reductionist analysis and system theoretical synthesis.

Elements of the Universeum design process illustrate integration-separation relations. The *attitude of the architect* is basic. He states that environmental awareness is an integrated part of all his design. The question whether *special environmental goals* are needed is also basic. The EAD model states that environmental goals, although separately formulated, should be part of the design brief. In the Universeum competition programme, environmental guidelines are given in a *separate appendix* form. Other important appendices, like the functional programme and the floor area programme, are also given as appendices. The appendix form therefore is interpreted as strengthening rather than weakening the environmental issues in the programme context. Issues discussed in Universeum's special *environmental design meetings* should rather have been an integrated part of all design discussions.

6.2 Setting Goals as a Design Element

From a design theory perspective, setting goals can be seen not only as pointing out the result aimed at in the design process, but also as part of the definition and handling of the problem, aimed at narrowing the field of uncertainty. Setting environmental goals thus could function as *motivating*, *problem identifying*, *communicative* and *guiding* elements of design. In the Universeum process, goals were set forth in documents from three different phases: The business plan, the architectural competition programme and the environmental programme. The first document was written and embraced by the proprietor himselt, but was not very operative. The other two were expert products, to a little extent involving the consultants in the goal setting activity, and thereby not fully utilising the design potential of a common setting of goals.

6.3 Symbol and Effect

The two environmental perspectives of *symbol* - cultural/architectonic and pedagogic intentions, symbolising the building's mission in it's architecture and trying to influence people's minds and behaviour in the long run - and *effect* - operative intentions of affecting the building's environmental performance from the start - can be seen as environmental influence from the project in two different time perspectives. The symbolic dimension in Universeum is articulated, e. g., in the extensive use of wooden structure (renewable material), an expressive sawtooth roof carrying photovoltaics (local energy transformation) and a biological wastewater treatment demonstration plant (food chain). Effects (that can not yet be measured) are exemplified, e. g., by energy conservation, a urine separation system (nutritive salt recycling) and a biological aquatic water purifier system.

6.4 Environmental costs

In Universeum, the message of formulations in the competition programme and the governmental financial contribution is: Environmental concern costs money. For the time being, this message might be accepted. But the question that follows will be: How much? Addressing environmental factors through integrated design can entail difficulties in calculating separate environmental costs. Such costs could be calculated only as additional costs to an alternative considered to be environmentally less advantageous. The comparison will be totally dependent on which alternative is used. Moreover, integrated solutions, e. g., natural ventilation, reducing costs for technical equipment but possibly increasing building costs, makes these calculations difficult. This calls for a focus on the lifecycle costs of integrated solutions as a whole, rather than calculating specific "environmental additional costs".

7. CONCLUSIONS

Handling environmental imperatives within building design processes calls for changed routines, not only in the form of additions to traditional design process organisation, but partly as new ways of starting up the process and new skills for design actors. Environmental aspects add new prerequisites to the architect's role of functional and aesthetic co-ordinator.

The environmental impact of buildings is a consequence of a chain of requirements elaborated from the first project ideas, thus calling for early design discussions on how to implement these ideas with an appropriate limitation on environmental load. These discussions should be part of the early design phases and should integrate the whole design team. In these discussions, early educational features and joint goal setting could be design process elements of great potential. Environmental goals must be part of the proprietor's intentions, and must be continually monitored and revised when justified.

The SD imperative stresses the importance of the programme phase in the design process, which is the phase where the developer and consultants can identify and adopt, to their specific project situation, explicit environmental goals to guide the integration of these aspects. There is a need for an environmental co-ordinator, who acts as design facilitator, focusing and mediating the integration of environmental aspects into design and building processes and promoting learning about Sustainable Development for all consultants and especially for the proprietor.

A "Table of reflections" based on impressions from the case study and suggesting design process factors of environmental importance conclude this paper.

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Table of reflections: Design process factors of environmental importance	
Factor	*Substance*
Motivated proprietor	A motivated proprietor is a basic prerequisite for success in an environmentally adapted design process.
Actors-integrated design process	All actors participating from the beginning make possible common environmental goal setting in early design phases.
Aspect-integrated design process	Environmental aspects should be continually identified and studied, but in an integral way, as part of a design totality.
Organisation for environmental design	Environmental organisational support to the design should be stated in an organisation plan approved by the proprietor.
Design facilitator	An "environmental process leader" should support the design process to secure continuous environmental design ambitions.
Environmental scrutiny 1	A project's environmental load primarily results from needs, wants and "necessities" which should be early scrutinised.
Project-related environmental education	A common education granted to all design process actors should be considered as a consensus creating element.
Goal setting	All actors should participate in setting environmental goals for the project, thus internalising these goals as their own.
Compiled, monitorable environmental goals	The result of the discussion on environmental objectives should be documented, and approved by the proprietor.
Planned goal monitoring	In the design schedule, checkpoints for controlling the fulfilment of environmental goals should be planned.
Documentation of changes in goals	As quality assurance and for learning reasons, revisions of the environmental goals should be documented, including motives.
Common check lists	In checklists for environmental design, issues common to the whole design team should be identified and compiled.
Environmental scrutiny 2	Project requirements turned into building design requirements should continually include environmental impact discussions.
Lifecycle- oriented systems design	Systems design phase should be lifecycle-oriented, with a system perspective on the use and maintenance phases.
Systems thinking in decisions	The building should be planned for adaptability to future environmental features as well as part systems renewal.
Planning for monitoring	Identifying data and systems for monitoring environmental performance should be part of the systems design.
Goal awareness	Measures should be taken to maintain the awareness of all actors of environmental goals during the design process.
Pressure on suppliers	Every project implies opportunities for raising environmental market standards.
Tools	Accessible, phase-adapted tools for education, goal setting, LCC calculation and environmental assessment are scarce.

Energy saving by synergy

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1.INTRODUCTION

In 1999 the Swedish Parliament set national environmental goals, many of which are adapted to Sweden´s international responsibilities. The most important ones deal with the infra-systems for transport, climatization of buildings and recycling of rest-products from households. All these goals also have implications for qualities of the built environment and land use in general.

In a first step (up to 2010) each one of the infra-systems for mobility, climatization and recycling has to be more eco-efficient in itself. These sub-optimizations will, however, not at all be sufficient for reaching the goals in the second step. For example: The use of energy in the built environment has to be reduced from about 200 to less than 150 kWh/m2 and year, by the year 2010, and reduced to less than 75 kWh/m2 and year at mid-century. The mobility system has to reduce CO2 emissions by 75 % during the same period. How to reach these goals is a wide open question, since after having successfully exhausted all more conventional measures we will be just half the way!

2. HYPOTHESIS

A combination of solar-based redesign (I), qualitative condensation of modern and post-modern built up areas (II), now often lacking good urban quality, and attractive fuel–cell-drive urban public transport systems (III) could realize "factor 4-sustainability" in our cities of tomorrow. This eco-efficiency can be upgraded even more when the fuel cells are run by bio-energy derived from our organic wastes and certain energy crops (IV).

3. PERSPECTIVE

The use of energy in the built environment and in the transport system, respectively, has always been regarded as two separate phenomena. But might they work together? In this paper the possibility of synergy between infra-systems will be discussed as a prerequisite for reaching the goals in a more integrated fashion up to 2050.

The new synergetic infra-systems we need must start being implemented already around 2010 to reach sufficient quantitative effect, especially with regard to the greenhouse syndrome, at mid-century. Hence they in fact have to be investigated immediately. Industrial design and architecture, based upon combined systems ecology and socio-technique, will have a great role to play. But it is not about post-modernism or neo-modernism*: it is still about innovative modernism for green solutions in a classic socially conscious way.*

This paper will focus on benefits analyzing some built and some mobile artifacts together:
What energy savings may be reached when we consider the existing built environment, new additional buildings, and an enlarged, attractive public transport system (and further on also

the private car system) as parts of the same local system for sustainable use of energy? New kinds of vehicles - bigger and smaller in versatile combinations and especially those in public use - will have a role to play in this. To realize such a perspective on infra-systems we really need some kind of a catalyst!

4. THE FUEL CELL AS A CATALYST

The fuel cell is in itself a catalyst – for snatching away electrons from hydrogen so that electricity will be created when water is formed. How might this natural process be exploited as a kind of catalyst for reaching the environmental goals? If the fuel cell can be made more of cheap and environment-friendly polymer, using less of the rare metal platinum, and if the heat that it also emits can be of a useful temperature, it may fit into the new perspective and the hypothesis above. (In this case the basic facts come from professor *Göran Lindbergh* at the Department of Chemical Engineering, The Royal Institute of Technology, Stockholm. He is one of the leading persons in the Swedish National Fuel Cell Program, run by MISTRA. In phase II of this program, starting in July 2002, the above-mentioned hypothesis will be investigated by the author, together with professor *Bengt Steen* and doctoral student *Magnus Karlström*, Chalmers University of Technology.)

The construction & design of vehicles that promote synergy between infra-systems has already started: buses with fuel cells are now being introduced in some European and North American cities (The CUTE project, supported by EU, starting 2002). The latest idea is also to develop bus-like light rail systems – without the trolley wire. Instead: every tram set may deliver both electricity and heat when not in use as a vehicle, i.e., nights and in low traffic periods (60% of total time), since the fuel cells are best used continuously. Thus more than half of the total energy capacity of the public tram/bus system may fit into and upgrade a (solar based – see below) building stock – strictly speaking even more, because in this usage you produce both electricity and heat.

The vehicle-borne “micro power” may be emitted both locally, direct to buildings and groups of buildings in neighborhoods, and to district heating systems, plus to the usual electrical power net. Without emissions or noise! In northerly regions this is of great interest as a means to alleviate the effect stress in our main energy system during the peak of the winter. Since one of the main motivations for retaining nuclear power in Sweden is the need to meet this effect stress, the micro power alternative could play an important role when closing down this kind of power stations in accordance with parliamentary decision. Another interesting consequence is that the net itself, in the district heating systems, will work together with both the micro power system and the central power-heat station. This will promote the environmental goal of not burning harmful materials and stuff that has been transported from too far away, as we often do now.

There is good reason to develop modularized and versatile vehicles of new kinds, with regard to the intricate role they may play: buses and trams certainly will be much more alike and have almost every component in common, when the fuel cell technology is installed in both of them. Both types of vehicles will work together and use much of the same infrastructure. They will in fact become two parts of the same system in future: buses servicing the urban periphery, and trams - in longer sets with fewer drivers (and just 15% of the friction!) - servicing the more dense city areas. Also smaller buses and mini-vehicles will be able to use the same flexible technology for many purposes: taxi transport, urban distribution and the transport of rest-products from urban areas to sites for reuse and processing. This brings us to

the next question: *From where do we get, in a sustainable way, all the hydrogen needed for the "public" vehicles and for their new "night job"?*

5. BASIC FUEL FROM ORGANIC WASTES AND ENERGY FARMING

Natural gas will of course be used, but that is not much better than using other fossil fuels. Photo-electric solar panels, artificial photo-synthesis, etc, will be able to produce hydrogen, but may be too expensive – in some years we will know. One interesting perspective leads us back to the interaction between buildings and vehicles again: design the buildings and the infra-systems to facilitate the possibility to transport hygienically the organic rest products from households to local hydrogen/methanol refineries around cities. That could be done by specially designed "eco-shuttles". When the shuttles leave the waste, after having pre-processed it on board (using the energy system there), they pick up the hydrogen/methanol at the very same place. The eco-shuttles then deliver the hydrogen to the public transport vehicles, wherever they are located logistically. If the benefit of better waste treatment this way can lower the fuel price, this may be an interesting concept.

That makes the eco-shuttles a part of the distribution system for hydrogen we need as an alternative to the fossil fuel distribution system. The different quantities go together. The more households in the city, the more organic wastes and the more basic fuel, but also: the bigger the public transport system. Because we need more hydrogen/methanol than is produced only this way, we can use some of the agricultural areas around cities. Since there is an over-production of corn within the EU, we might very well start using some acreage for this purpose instead. If the benefit of an open landscape can lower the fuel price, this may be an interesting concept. Unlike energy-wood on farming land the production of plant-like material for fermentation will keep the landscape open, and it is easy to switch back to different other crops as needed. The areas used in this way will in fact be fertilized by importing (good) rest products from the fermentation.

(See appendix, where some quantities are calculated for the City of Uppsala. Facts in this case come from *Ola Palm* and *Åke Nordberg*, at the Swedish Institute of Agricultural Environmental Engineering, Uppsala. Facts relating to producing hydrogen via organic processes come from professor *Peter Lindblad,* Dept. of Physiological Botany, EBC, University of Uppsala.)

6. URBAN RE-DESIGN

Above, some of the parts of the synergetic system described in the hypothesis, have been mentioned: the fuel cell technology, new vehicles, that may be powered by fuel cells installed onboard, and the sustainable production-distribution of hydrogen for these vehicles. Let us now consider urban re-design and solar-based buildings, fitting them into the system.

We can imagine a final stage of the urbanization process: in a couple of decades ¾ of the global population will live in urban agglomerates. Already this year, almost half the population is urbanized and, furthermore, in an unsustainable way. At the same time the richest ¼ consume ¾ of the resources of the world. That means that both the very rich and the very poor will live in cities - often in the same metropolitan area. Social segregation may be expected to increase, especially in the bigger cities.

Sustainable land use has to respect, preferably enhance, quality of life as far as possible. We have to combine some degree of urban condensation with urban livability. The developing countries must be helped to increase their welfare-generating everyday mobility by smart

public transport systems *long before* they can afford private cars. And the rich world will have to consider the following fact: Even without any growth in the economy, we will have 50% more cars in some years, just following the current trend. Therefore, we shall have to use our cars, as cars, about half as much as we do now, in urban areas especially. Two things are important: people must have a very attractive public transport alternative for everyday use, besides bicycling and walking, and they must have the opportunity to park their cars somewhere. Both built up spaces and green spaces will feel the squeeze, even before any urban condensation.

But qualitative urban condensation could, as discussed above, explicitly combine planning for public transport and solar-based re-design of the building stock. The question of quality of buildings may then be dealt with in some new ways: areas of medium quality can be made more accessible and therefore better to use, areas of bad quality can be both upgraded and become more accessible, and the buildings and installations we do not want to re-design are indirectly helped by a higher eco-efficiency in the built up structure in general.

Also the fleet of private cars, when parked and equipped with fuel cells in the future, could contribute to the climatization of buildings. In fact, the car will be able to pay for its own parking when it is productive also standing still. That means that less extensive parking can be paid for, for example, underneath buildings which cars are supplying with energy. Such condensation might contribute to a better urban outdoor neighborhood environment and would be in line with environmental goals if the hydrogen itself is generated in a sustainable way.(Note: the bio-energy base within and around cities, as discussed above for the public transport system, will never be big enough for the whole private car fleet, though).

Urban condensation, based on future public urban transport, need not be compact: especially new forms of bus-like light rail systems (with fuel cells and therefore without the expensive trolley wire) will be much easier to expand organically and combine with bus service. Therefore, the valuable accessibility such systems generate in built up areas may combine efficiency with a certain degree of green porosity in the urban structure. Just one minute of travelling anywhere in the system corresponds to one kilometer of new accessibility in the urban periphery. So, the widespread idea that urban condensation always means a compact city is not correct. (Probably it is more based on a false alliance between green idealism about a city just for walking and cycling and the developers´ dream of a still more profitable exploitation?)

Suitably condensed and redesigned, the urban environment in a couple of decades might consist of around 25% flats designed for solar-based climatization, upgraded by some per cent of energy from the fuel cells of the public transport vehicle fleet (both directly and via the district heating network).

7. SOLAR BASED BUILDINGS

Energy from fuel cells is too high-grade (“exergetically”) to be used for climatization. Some studies (within the Swedish Fuel Cell Program, Mistra) say that it will be many times more expensive to heat, cool, ventilate, etc., a building by fuel cells, than by traditional means alone. But a solar-based building could probably be climatized that way, if the energy system of the building is *upgraded* by fuel cells and those cells are a part of a vehicle that is very useful the rest of its time. At the Royal Institute of Technology, Dep. of Energy Systems, we have tried to explore that concept (*CoolSol*, KTH-rapport från Energiteknik och Industriell Ekonomi och Organisation, 2000).

Our research shows that an electric-hybrid car (Toyota Prius, about 100kW) has to upgrade a normal flat only ten hours per year if the building (Kantorn in Uppsala, built in 1968, with ten flats per stair-well) (1) has a low-temperature solar roof, (2) ¼ of the facade has high temperature solar panels, (3) there is a water-based system for energy accumulation with some bore holes in the ground for long term accumulation and (4) a water tank in the stair-well for short term accumulation. To regulate the balance between the components over the year you also need (5) an energy pump, that works in a very suitable temperature interval. A fuel cell car would, of course be even better than the electric-hybrid, which is still using gasoline and emits both CO2, etc., and noise. But we wanted to use something already on the market for our calculations. In future a special kind of vehicle especially designed for those multi-purposes may be available.

Flats on a new top floor were added to the building when it was re-designed for the solar energy concept. The flats help finance the installations. At the same time, all the other flats were switched over to the new energy system. The whole block was made sustainable in this respect. Its share of the total effect stress in the community, during the peak of the winter, is almost nil. On the contrary: if the large-scale energy systems are blocked during extremely cold conditions, this building will not be affected as much as the others, due to the accumulating system and its readiness to receive vehicle-borne energy (both electricity and heat).

The *CoolSol* investigation indicates that the energy cost is almost competitive with other conventional energy systems even today. The concept will, furthermore, be almost independent from changes in the (world) market prices, which we have to expect for oil, natural gas and electricity. The main cost for *CoolSol* are installation costs, and these may be slimmed by innovative technology procurement and integration and upgrading of other qualities of the built environment.

8. APPENDIX

In a city like Uppsala (around 190.000 inhabitants,1/6 of Stockholm, a very common size of a city around the world) organic wastes , complemented with energy crops, could generate 200-400 GWh/year (at a low estimate). A complete light rail system will demand around 50 GWh/year (100 vehicles used 10 hours a day). If those vehicles could contribute energy (power and heat) into the built structure of the city during the nights, another 50 GWh/year are consumed this way. Altogether this could easily be generated within the bio-energy potential of the municipality. A corresponding bus system would demand at least double the capacity, but this, too, will fit into the limits of locally produced hydrogen from bio-bases. The potential is calculated so that areas used for crops and other kinds of food production will not be occupied.

Suitably condensed and redesigned, the built environment in a couple of decades might consist of around 25% flats designed for solar-based climatization and upgraded by some per cent energy from the fuel cells of the public transport vehicle fleet (both direct and indirect via the district heating network).The resulting eco-efficiency will be considerable if this redesign of infra-systems, technologically refined, were to continue up to mid-century. The redesigned and the unchanged buildings together have a chance to reach the environmental goal of reducing energy consumption by 50 per cent. About the same applies to the transport system because of the change of everyday travel habits (in spite of widespread car

ownership). The environmental goal concerning re-circulation of organic wastes may also be reached.

Keywords: environmental goals, climatization, synergy, vehicle borne fuel cells, solar buildings.

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Total Quality: The Basic Building Design Concept of the Austrian, German and Swiss Brick and Tile Industry

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1. INTRODUCTION

In 2000 the „GBC-Handbook of the D-A-CH (German, Austrian and Swiss) Brick and Tile Industry“ was published. The overall aim was to adapt the criteria of the international Green Building Challenge (GBC) assessment framework to national conditions and market needs of the brick and tile industry. Each of the basic GBC criteria is dealt with in detail, special consideration is given to the choice of materials. The handbook especially provides information how to proceed in order to achieve best assessment results when using bricks and tiles. As bricks combine qualities like indoor climate quality, noise protection, thermal capacity, fire protection, thermal insulation, longevity and flexibility the use of bricks turns out to be a major advantage with respect to a comprehensive building assessment. Furthermore, this handbook of the brick and tile industry turned out to be an essential contribution to the development of the Austrian Total Quality (TQ) Information Package described in detail in the report of these proceedings: S. Geissler, M. Bruck “Total Quality (TQ) Assessment as the Basis for Building Certification in Austria”.

2. THE TOTAL QUALITY (TQ) ASSESSMENT TOOL

The TQ tool provides a broad range of performance parameters:

Resource Consumption	*Durability*
Energy	Flexibility and adaptability
Land	Maintenance Management
Water	*Safety and Security*
Materials	Intrusion systems
Environm. Loadings/Impacts on Human Health	Fire protection
Atmospheric emissions	Barrier free buildings
Solid waste	Earth quake damage protection
Waste water	High voltage electromagnetic pollution
Critical materials	Flood protection
Commuting transport	Land glide protection
Radon	Avalanche protection
Electromagnetic pollution	Lightning protection
Mould	*Quality of the Design Process*
Indoor Environmental Quality	*Quality of the Construction Process*
Air quality and ventilation	Construction supervision
Thermal comfort	Final inspections
Daylight	*Quality of Amenities and Site*
Access to direct sunlight in winter	Access to public transport and other services
Sound insulation	

3. EXPERIENCES GAINED ON THE AUSTRIAN MARKET

Since summer 2001 – the date of introduction of this assessment tool to the Austrian market – TQ (Total Quality) certificates for 9 Austrian projects have been ordered. The system is used as a design as well as an evaluation tool (both for new buildings and renovation projects):

Design tool: The builder defines obligating requirement profiles for the individual planning fields (architectural concept, technical building equipment ...).

Evaluation Tool: The project is assessed twice: At the end of the planning process the "Planning Quality Assessment Certificate" is issued and at the end of the construction process (including measurements of the air tightness, noise protection and infrared thermography) the "TQ Certificate of the Built Project" is issued.

The certificates are used as marketing instruments to demonstrate outstanding project qualities and thus to assure a high degree of capital preservation for the investors. All details as well as certificates of already assessed projects are presented on www.iswb.at - heading "TQ".

4. PROJECT ASSESSMENT IN DETAIL: EXAMPLE "VINEYARD VILLAGE"

The realty located in the prestigious Viennese district Döbling borders on the old wine-grower's village Pötzleinsdorf. The owner IG (Immobilien GesmbH) decided to erect a building with 17 luxury apartments in exclusive design - sauna and low energy indoor pool integrated. The shape of the building was adapted to the hilly site, spacious balconies offer great views on the quiet surroundings (vineyards, gardens,...) and the hills above (Cobenzl and Kahlenberg). The simple geometrical shape of the building in combination with brick walls with external insulation contributes to the reduction of transmission losses. Large solar windows optimise the passive solar gains. Air conditioning is installed in the attic apartments. The indoor pool will be covered if not in use allowing a reduction of the air temperature below the water temperature without causing extreme evaporation losses. The insulation is partially located inside in order to avoid surface condensation and to guarantee quick up-heating. During the design process detailed planning targets were developed. The property maintenance management is carried out by the IG–Facility Management department thus ensuring outstanding quality combined with economic operation.

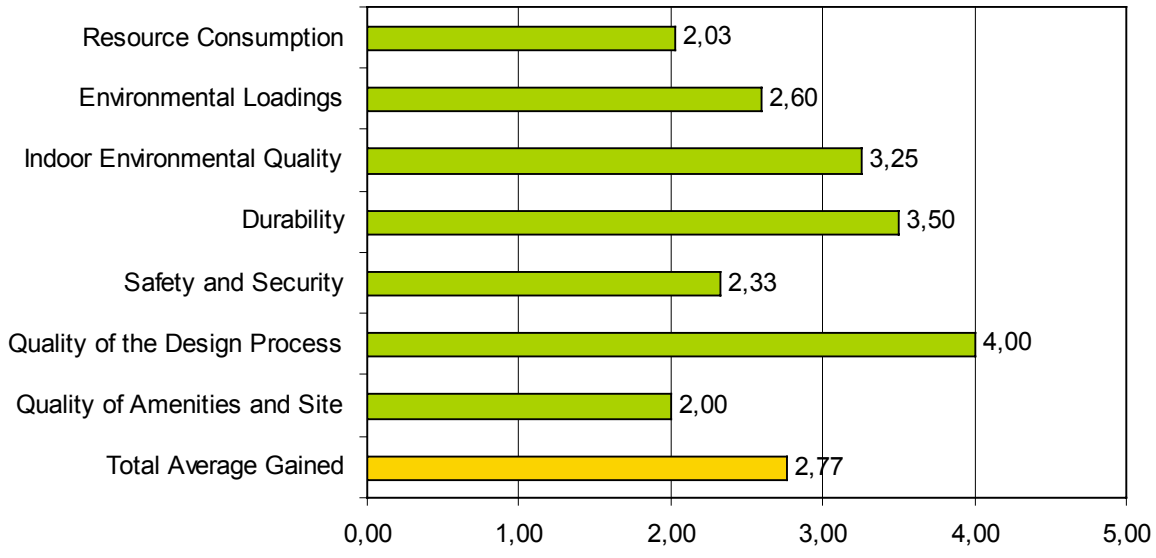

Figure 1: Issue level results of the evaluation – Example: Vineyard Village

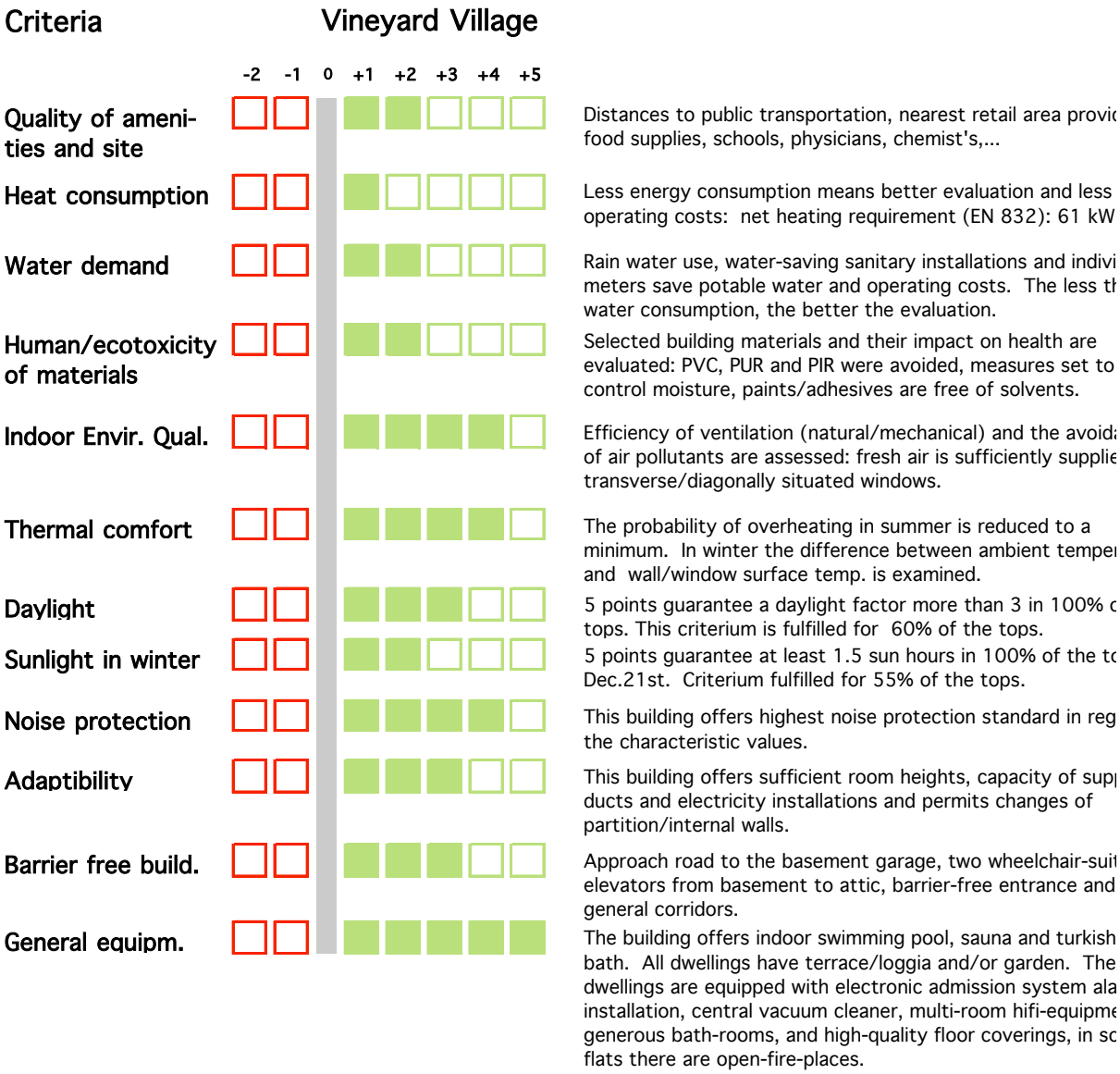

Figure 2: According to the results of a tenant inquiry carried out as part of the Total Quality project 12 criteria with special meaning for the inhabitants and the according assessment results are presented in the certificate (Example: Vineyard Village).

5. TOTAL QUALITY ASSESSMENT PROJECTS OF THE AUSTRIAN BRICK AND TILE INDUSTRY

The Austrian brick and tile industry is sponsoring the assessment of four ultra low-energy houses ("passive houses"). All projects have the following common characteristics:

- Net heat requirement for space heating (calculated according to EN 832) < 15 kWh/(m²a)
- High air tightness: $n_{50} < 0.6\ h^{-1}$
- Mechanical ventilation systems with heat recovery (heat exchanger efficiencies > 75 %)
- Prevention of thermal bridges
- Projects (5.1-5.3): Brick cavity walls: U<0.15 W/(m²K)
- Project (5.4): concrete framework with infill clay brick masonry + facing clay brick masonry (frost resistant) with U=0.15 W/(m²K)

Total Quality assessment is not only applied in Austria but also spreads to Switzerland and Germany. One German and two Swiss projects will be evaluated within 2002.

5.1 Row houses „Hamoder IV/3“, Linz (Upper Austria)
Builder: WAG - Wohnungsanlagen Gesellschaft m.b.H., Linz

In Linz Bindermichl (Upper Austria) 14 coupled row houses (total gross floor area: 2,645 m²; building area: 1,571 m²) will be established until 2003. Each house has a usable floor area of 121m² (11m² loggia, 38m² balcony and 48m² cellar not included). The building arrangement following the swung course of the adjoining road results in a south-east orientation along the striking southern edge of the hilly site. In order to optimise the heat-exchanging surface two row houses – each of them two-storied – are built together, these units are separated by single-storey garages. Because of the proximity to the motorway it was necessary to tighten up the requirements of noise protection. The rooms in the ground floor have large south and/or south-east oriented glazing in order to optimise the passive solar gains. HVAC in short: Each house is designed as ultra-low-energy house („passive house“) expected to be heated by a small air/air heat pump (1.4 kW) covering 82% of the maximally arising heating load. On very cold winter days it will be supported by an electrical backup heating system in bath and kitchen (capacity: 150 W). For ventilation and air heating a mechanical ventilation system with heat recovery in combination with a ground coupled heat exchanger is foreseen. Hot water will be prepared by roof-integrated solar collectors (additional heating is supplied by an electrical resistance heater).

5.2 Multi family house „Telfs/Puite“ (The Tyrol - Austria)
Builder: WE - Wohnungseigentum, Innsbruck

Telfs - the third biggest municipality of the Tyrol – is establishing about 300 flats in one of its localities called Puite, connecting two existing residential areas. In three stages these new dwellings are designed by several builders and architects. One of the projects will be carried out as a „brick demonstration project“ showing that the selected type of construction - brick cavity walls - is the best solution in order to achieve „ultra low-energy quality“ in combination with longevity and minimal maintenance costs of the external walls. This particular building project consists of two solidia with 36 flats. Besides ecological aspects topics such as Feng Shui and electro-biological installations play an important role in the overall design concept. HVAC in short: mechanical ventilation system with heat recovery (efficiency: 85-90%) in combination with a ground-coupled heat exchanger, heating of the preheated fresh air by a gas condensing furnace, solar hot water preparation.

5.3 Multi family house „Graz-Seiersberg“ (Styria - Austria)
Builder: GWS-Gemeinnützige Alpenländische Gesellschaft für Wohnungsbau und Siedlungswesen m.b.H., Graz

The real estate (total site area approx. 30,000 m²) was topic of a consultants‘ pre-project and a competition made by two local builders GWS and Neue Heimat. The dominating competition criteria were economic efficiency and energy conservation. Altogether approximately 300 dwellings in low-energy houses will be established within the next two years. One of the buildings will be designed as „brick passive house“ (with 16 dwellings, sizes: 73-89 m²; total usable floor area: 1,270m²). Commencement of construction: 2004; HVAC: mechanical ventilation with heat recovery, solar collectors for hot water preparation.



Figure 3: Multi family house „Graz-Seiersberg"

5.4 Multi family house "Wienerberg City, F1" (Vienna)
Builder: GEBOES - Gemeinnützige Baugenossenschaft österreichischer Siedler und Mieter, Vienna

If one approaches Vienna from the South one „double" multi-storied building dominates the skyline of the city - „The Twin Towers". Nearby a new urban expansion area has been developed – called the „Wienerberg City" – green surroundings in proximity and plenty of leisure-time facilities offered by the entertainment centre "Vienna Twin Park". Approximately 1,300 dwellings will be built there within the next two years. One of the winning projects of the builders' competition was the concept of a multi-storey brick house in passive house quality with 97 dwellings (sizes between 54 and 102m²) whereby high attention was paid to ecological and economic criteria. Total usable floor area of dwellings: 6,880m² (11 floors above, two floors below ground). Because of east/west orientation and shading by neighbours it was not possible to maximise the solar radiation by large windows, therefore the architectural concept had to follow the need of loss minimisation – „small openings in a large volume" to achieve the requirement of a passive house. The main dwelling complex (2nd to 10th floor) is architecturally separated from the double-storey base range (consisting of ground/first floor) where a café, a chemist's shop, the administrative centre of the building owner, secondary rooms and the entrances to the three staircases are located. By an arcade, in which a building passage is integrated, the open space is increased and the base area partly opened. The last two storeys consist of large maisonettes built with monolithic brickwork. A flexible ground plan guarantees that between two flats one room can be allied either to the one or to the other dwelling in case of need (family increase - growing children, multi-generation dwellings, group houses or alternative living forms). All external walls (concrete framework with infill clay brick masonry + facing clay brick masonry) are highly-thermal insulated with ecologically recommended materials. The main heating requirement is provided by a mechanical ventilation system with heat recovery (fresh air change rate: 0.2 h^{-1}) combined with a ground coupled heat exchanger, necessary backup heating energy is provided by a central gas furnace, hot water preparation partly by roof-integrated solar collectors.

5.5 Demonstration building project „Ziegel-Aktiv-Haus“ („Brick-Active-House“), Celle-Germany

Builder: ARGE Mauerziegel, Bonn

The Fraunhofer Institute for building physics started a demonstration project together with about 50 industrial partners in Celle near Hannover in order to erect 11 different „3-Litres-Houses“ – single or duplex houses – (annual primary energy consumption for space heating of less than 34 kWh/(m²a) - this corresponds to a primary energy content of 3 litres fuel oil). The „Ziegel-Aktiv-Haus“ (Brick-Active-House) is a duplex house (total usable floor area: 2×138 m²) completed in summer 2001. Now the efficiency of the different HVAC systems installed in part A and B (see Table 1) will be evaluated over 2 heating seasons. The garden-laterally large window front to the south forms an ideal condition for the highest possible solar energy utilisation and moveable shading devices exclude overheating in summer. The roof pitch (34°) was selected in regard to an optimised solar energy use by collectors and photovoltaic systems. The massive type of construction of the inner walls and ceilings stores heat during day and releases warmth during night, therefore contributes to pleasant summer ambient temperatures and enables at the same time the installation of a low-loss heating system with lowest operational temperatures.

Table 1: Different HVAC systems in the duplex house “Ziegel-Aktiv-Haus”, Celle

HVAC	House A	House B
Heating System	Gas condensing boiler 3.5 – 11 kW	Gas condensing boiler 3.5 – 11 kW
Heating Supply	Wall heating system 35/28°C	Radiators 55/45°C
Control	Individual room control	Thermostatic valves
Solar Collectors	Vacuum collectors for heating support and hot water preparation	Vacuum collectors for hot water preparation
Storage	Buffer storage	Solar boiler
Ventilation	Natural ventilation	Mechanical ventilation (heat recovery = 90%)
Auxiliary Electricity	12 m² photovoltaic system	Local supplier

5.6 Multi-unit family house „Kurfürst-Enge“ (Zurich, Switzerland)

A leasehold house dating from the 40-ies of the last century was located on the building site. A detailed cost/benefit evaluation of the advantages/disadvantages of renovation versus demolition plus establishment of a new building was carried out. The optimisation process led to the decision to erect a new low energy 3-storey building made of cavity walls and fair-faced brickwork. The seven tops have relatively large and high living rooms (height: 3 m) with high daylight quality. Large balconies offer a closer contact to the green ambience. High indoor air quality is achieved by using mechanical ventilation system.

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Recycling and Local Use of Materials at Fornebu

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INTRODUCTION

Norway's main airport, Fornebu was closed in 1998. The area of 3,4 km^2 will within ten years change into a new city district with more than 6000 households and 25.000 workplaces.

The principal owners, The Norwegian state represented by the Directorate of Public Construction and Property (Statsbygg) and the Municipality of Oslo, prepared in 1999, together with the Municipality of Bærum an environmental program for the development of the Fornebu area. The program was concentrated around five environmental issues, and became a part of Bærum Municipalty's master plan for Fornebu. One of the main issues was maximum reuse and recycling of local resources within Fornebu.

During the demolition and construction period there will be generated a large amount of by-products, such as old asphalt, concrete, rock and soil. Reuse and recycling of these existing materials at Fornebu will limit the transport in and out of the area, and in a wider sense extend the natural resources of rock in the Oslo area.

A lot of work was done to examine the potential of local reuse and recycling, and map the resources at Fornebu. Finally a masterplan for the mass management at Fornebu was worked out in 2000. The plan is based on a main vision that no masses should be transported out of the area and that new high-grade end-use should be given priority before landfilling.

The new suggested high- grade reuse needed further development to be carried out, and R&D projects were initialised on production of soil, recycling of asphalt and concrete and on optimal environmental solutions.

STRATEGY FOR THE OVERALL MASS MANAGEMENT

The early estimates in the mass management masterplan are used here to illustrate the quantities of available masses. The description of the end-products and end-use are based on the priorities in the master plan and experience from the first year of production and sale at the local recycling plant.

Available masses at Fornebu

The available masses at Fornebu are divided into the following types (see fig.1):

- *Construction and demolition waste (C&D-waste)*
  C&D-waste, mainly concrete and masonry, are generated from buildings that earlier were part of the airport activity, but now are demolished as a part of the new development of the area. The quantity is very uncertain because some of the buildings will be protected

and some are rebuilt and renovated for new use. Early numbers estimate the quantity to be 50.000 m^3 +/- 50%.

- *Old run- and taxiways*
  When the airport closed down the Fornebu area included totally more than 120.000 m^3 of asphalt. In some areas the asphalt is more than a half meter thick because of repeated maintenance of the asphalt surfaces. Some of the asphalt is contaminated with PAH and is treated separately by a specific project in Statsbygg.
- *Blasted rock*
  Blasted rock is generated from the construction of new ditches and roads, or changes in the landscape, but mainly from the construction of basements for the buildings.
- *Other quality-masses*
  Underneath the old run- and taxiways are quality-masses that have previous been supplied to Fornebu. The most important resource is a large sand deposit under the old runways, estimated to include nearly 150.000 m^3 of supplied sand. In addition some of the old road-base materials and the soil can be reused or recycled.
- *Unsorted excavated masses*
  The unsorted excavated masses are also mainly previously supplied to Fornebu, either to the waste deposit that existed before the airport was built, or as part of construction of the flat airport area. The masses include old C&D-waste from Oslo city, clay, soil and blasted rock. Some of the masses are contaminated and are handled separately. As part of forming the new landscape, large quantities of these masses are to be excavated and replaced. In addition, the treatment of the contaminated masses and the construction work generates large quantities of excavated masses. The total quantity is very uncertain, but early numbers indicate that up to 1.000.000 m^3 of excavated masses are to be replaced within the area.

End-products and end-use

Statsbygg works with a contractor for handling the masses that are to be recycled. Fornebu Gjenvinning ANS is responsible for the production and the quality of the end-products. The company is also responsible for the acceptance of incoming materials at the recycling plant.

Every month Statsbygg orders a specified production at the recycling plant based on orders received from the different contractors at Fornebu. Statsbygg also informs the contractor about incoming quantities to the plant and amounts to be sold each month.

The recycling plant consists of one mobile impact-crusher for the production of crushed concrete, asphalt and rock, and a tumble-screen for the production of soil. Both are electrical driven because of the endurance of the Fornebu project.

The end-products that are produced at the plant are mainly (see fig. 1):

- *Crushed concrete*
  Crushed concrete is produced from the local C&D-waste. It's now mainly crushed into a product of 0-50 mm for use in road construction. But it's also of interest to produce fractions without fines for use in ditches, around buildings and possibly in the production of new concrete.

- *Crushed asphalt*
  Crushed asphalt is produced form the old run- and taxiways and is crushed into a product of 0-50 mm. It's used in road construction, mainly in the base and sub-base.

  The challenge has been to achieve acceptance of using the unbound crushed asphalt in high traffic roads and in the upper layers of the construction. Results from a pilot project with combined field- and laboratory tests shows that the crushed asphalt and the concrete can have the same, or better performance than natural aggregates in roads. Based on the results the new heavy trafficked road into Fornebu was built with 30 cm of crushed asphalt in the sub-base. The next step will be to document use of unbound crushed asphalt in the upper layers of less trafficked roads.

- *Crushed rock*
  Blasted rock is mainly crushed into products of 0-4 mm, 4-16 mm and 16-32 mm for use in ditches. The bedrock at Fornebu is a limestone/mudstone, and is not very suited for high-grade use in roads. The crushed rock is therefore mainly planned used in the construction of ditches, while the crushed asphalt and concrete are used in the roads.

  In construction of ditches the product of 8-16 mm is customary, and was also produced at the plant in the beginning. The problem was that the production of 8-16 mm also generated almost 45% of 0-8 mm that have no specific end-use or market value at Fornebu. The challenge has therefore been to minimise the amount of fines by specifying use of larger gradings in the ditches were it's possible. By instead, producing 4-16 mm and 16-32 mm the amount of fines is lowered to 20 %. Fortunately the quality of the lime-rich rock also makes it possible to use up to 25% fines in the new soil.

- *New soil*
  The new soil, for use in the green areas is produced from different recipes that is developed based on the available resources at Fornebu. The ingredients are:
    - Excavated soil
    - Sand form the deposits
    - Sorted excavated masses
    - Fines from aggregate production
    - Composted sludge (supplied)

The new Fornebu will contain extensive green areas and therefore also needs large quantities of new soil. The demand is estimated to be about 400.000 m^3 in the common green areas.

Statsbygg's goal is that all the needed soil for the common green areas, and 90% of the heavy building materials for the construction of common roads and ditches are supplied from the recycling plant.

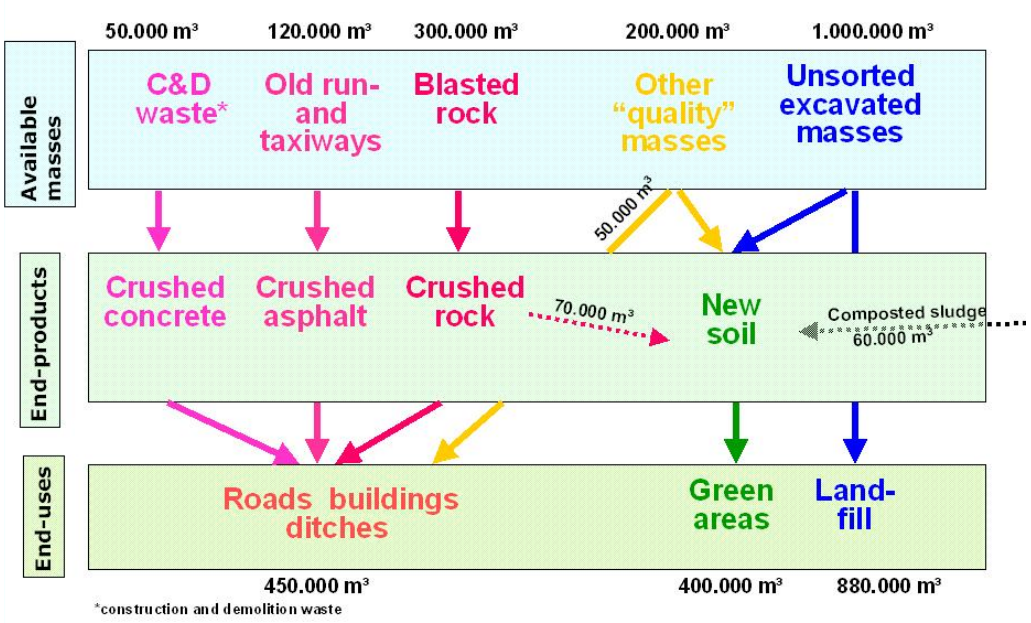

Figure 1 Principles for the mass management strategy at Fornebu

ADMINISTRATION AND COORDINATION

Statsbygg is coordinating the demand and excess of masses between the projects, and also update a total mass-account for Fornebu. Projects use the recycling plant have to follow a system for reporting of mass excess and demands to Statsbygg. The reporting makes it possible to coordinate the recycled materials between the different projects and to plan the production at the plant.

The users also have to sign an agreement of "rebuy". Projects that deliver excess of asphalt and concrete to the recycling plant have to "rebuy" the crushed products within a specified period.

The profit for each project lies in the decrease of transport needs and product costs. The sales-prices are the same for all the projects, and the recycling plant itself is based on a "non-profit" principle. In that way, all the users have the same advantage of using the plant.

CONCLUSION

Statsbygg handles only a limited part of the masses at Fornebu, and in order to reach the overall goal it is essential that all the real-estate developers at Fornebu include the strategy in their planning.

The strategy demands particular focus on mass management in engineering and progress planning in every project. It's necessary to put down much work in tailoring the descriptions of end-products in the tender documents and specifications, based on the available masses.

If Fornebu succeeds with the mass management strategy, a major part of the ditches, green areas and roads at Fornebu will be constructed from the local by-products. It can give a reduction in transport needs equal to 80.000 truckloads driving into Fornebu within the

development period, in addition to the masses that normally would have to be transported out of the area.

Your Home –
Australia's New Sustainable Home Design Guide

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BACKGROUND

Australian housing has a significant detrimental impact on the natural environment. The construction, operation and demolition of housing is responsible for impacts such as the production of greenhouse gas emissions, reduction of air quality, stormwater runoff, degradation of groundwater systems and the depletion of scare natural resources. Research has found that the share of greenhouse gas emissions from the building sector represents some 25 percent of the total Australian energy related emissions and is increasing at a rate faster than the total energy related emissions (AGO, 1999).

Many market failures exist leading to a scenario whereby the full environmental cost of resources is rarely transferred to the end user. Governments have traditionally sought to address these market failures through the education of stakeholders and the development of best practice guidelines for each specific environmental issue. This approach has seen the proliferation of single issue guide materials in various formats pitched at various technical levels, championed by numerous government agencies, building industry organizations and community groups. Most publications dealt with the supply of technically superior buildings assuming a market would naturally occur.

The inconsistency of publication types, varying formats, differing technical levels, and range of environmental issues covered without a well developed market, meant that the majority of residential building designers and builders were reluctant to seek education in the area and reticent to use the readily available guide materials.

In the past five years Australia has also witnessed a growing number of highly popular books and other media stories describing how particular houses were built or renovated to be more environmentally sustainable. Growing awareness of the need to address environmental issues outlined in these stories has started a groundswell of interest in environmental sustainability for housing, although it remained a small market niche with few large-scale developers seeking to address the environmental impact of their products. A study of house plans submitted for approval found that less than 3% of all houses could be described as having the features of passive solar design (AGO, 2000).

In 1997, the Prime Minister, Mr John Howard in his statement "Safeguarding the Future" committed the Australian Government to a program of action to address global climate issues. An important part of Australia's commitment was the formation of the Australian Greenhouse Office as the lead Commonwealth agency on greenhouse matters.

Following extensive consultation with the building and construction industry, the Australian Government agreed on a dual approach of mandatory energy performance requirements complemented by voluntary best practice initiatives. Minimum energy performance standards for all new and refurbished buildings are to be introduced into the Building Code of Australia from 2003, and the Australian Greenhouse Office is providing funding support for industry designed and delivered best practice initiatives. The forthcoming regulatory change has magnified practitioner interest in technical materials on energy efficiency and low greenhouse emission building design.

In 1998 and 1999 the Australian Greenhouse Office received numerous funding requests for greenhouse specific guides from many different stakeholder groups and the extension of existing guides to include greenhouse gas emission reduction sections. Requests came from community groups, industry representative organisations and other government agencies.

Late in 1999 the Australian Greenhouse Office received an approach from the National Office of Local Government to fund the greenhouse addition to "Australia's guide to good residential design" a popular semi technical guidebook for city planners. During negotiations for funding support, several Commonwealth Government agencies agreed to work together to develop a more comprehensive guide covering a greater variety of environmental issues. The Australian Greenhouse Office agreed to lead the project and immediately sought to gather stakeholder support, corporate sponsorship and suitable technical expertise.

Tenders were called to develop materials for the Good Residential Design Guide project, later to be branded "Your Home", with the explicit goal of creating a single guide to reducing the environmental impact of Australia's housing stock. The guide was to go beyond the single issue focus of previous materials and be designed to communicate a range of practical solutions to a broad audience group with varying levels of technical understanding in the field.

An early commitment by all partner organisations to utilize the materials to update and educate their members became a significant part of the strategy to disseminate the materials.

Following the contracting of the Institute for Sustainable Futures (ISF) as the primary consultants, a peer group of technical experts was contracted to support the steering and stakeholder representative committees and provide systematic assessment and improvement of all technical materials.

The ISF approach to the project was strongly influenced by "Innovation Diffusion Theory", a tried and proven social change tool (Rogers, 1962 & 1971). The following extract from Alan AtKisson's (1999) describes Innovation Diffusion Theory as it applies to the field of sustainability and, in doing so, encapsulates the theoretical underpinnings of Your Home [5].

> *"I call the early adopters Transformers, for two reasons: They are the real doorkeepers to the transformation of a culture, and they often work like an electrical transformer, stepping down the voltage of the innovation and easing it into the mainstream gradually, at a speed the system can safely absorb.*
>
> *Transformers are leaders among mainstream people (in the group, the company, or the society at large), who are open to new ideas but cautious about which ones they promote, because they want to maintain their status.*
>
> *If the Transformers embrace an idea, the Mainstreamers (the majority of the culture in question, who watch the Transformers for cues on what new ideas to adopt) are almost sure to follow (perhaps at a safe distance).*

To make sure that the Mainstreamers do follow their lead, the Transformers may alter the idea by toning it down, reducing its radicalness, using it in a way the Innovator never intended, or using only part of it".

AtKisson's "transformers" are beginning to establish a presence in the Australian housing market aided by government and industry sponsored schemes that recognise, reward and promote excellence in sustainable innovation. They are consumers, designers and builders who embrace the ideals of sustainability, cleverly selecting and adapting innovations to fit within the real constraints of budget, climate and availability. As AtKisson observes, this rarely meets the expectations of the "innovators" but is an essential step towards achieving "mainstreaming".

Your Home is a "transformer" by AtKisson's definition. It is intended to break down the complexity of sustainable theory and ease it into mainstream home building practices allowing industry to absorb it at an achievable pace. Whilst Your Home identifies and recommends best practice in every case, it also encourages partial implementation of all principles at every opportunity and encourages participation over perfection.

METHODOLOGY

An initial literature review revealed an abundance of literature and technical information on innovation to improve the sustainable performance of Australian housing stock. This literature has been widely available since the early 70s. Two key research questions quickly emerged:

- Why was the innovation transformation process stalled?
- How could the materials best act as a catalyst for "innovation diffusion" or "mainstreaming"?

Analysis of the existing literature lead to the conclusion that it had not been "designed" to effectively communicate with a mainstream audience. It was designed for an audience of innovators and was likely to remain the exclusive domain of that group until it was transformed into the language of AtKisson's mainstreamers.

COMMUNICATIONS RESEARCH

A leading research consultant, Professor Robyn Penman was engaged by ISF to investigate the audience information needs and develop a communications strategy for the project.

Audience analysis

The research team analysed the various factions within the potential audience and mapped the complex interactions required between them to "mainstream" the subject material. For the scope of this paper, the range of factions has been summarised as: consumers, designers, builders, regulators, marketers, manufacturers, and researchers/innovators.

Several key observations were drawn from this analysis:

- The information needs of each group were quite diverse. It was unlikely that a single document or media form would meet the information needs of all groups effectively.
- Many consumers had little knowledge of environmental sustainability or why it was important to the local or global community. Others had substantial awareness but believed that sustainable features were too expensive or unavailable to them.
- Those consumers who did attempt to include sustainable features in their homes experienced difficulty accessing designers and builders with adequate skills to implement their ideas.
- Whilst designers were generally more aware of the basic principles, they lacked the specific skills and information to implement them.

- In the absence of demand from consumers or direction from designers, builders saw little incentive to make their products more sustainable
- Marketers (eg. real estate agents, project home companies and developers) largely generated their own perceptions based on close observation and prediction of consumer behaviour. Whilst very influential in the market, their actions are largely driven by majority consumer preference.
- The information needs of regulators, manufacturers and innovators were adequately met by the existing "technical" literature". Regulators were driving reform as rapidly as market acceptance would allow. Innovators were restricted by the lack of market uptake and manufacturers were developing new products in line with market demand.

A clear picture had emerged of the importance and mutual influence of three groups: consumers, designers and builders. Each had a distinct but essential role in "mainstreaming" sustainable features in Australian housing and, equally importantly, the roles were interdependent. The research found that the range of information available to the three groups was inadequate, being either too technical, lacking in practical application or too diverse with the vast range of imperatives found to be confusing to most of the audience. In consultation with all stakeholders, it was decided that a focus on these three audience groups would best fulfil the objectives of the project in terms of mainstreaming sustainable housing.

Audience research

Exploratory research using in-depth conversations with small numbers of people was used to expose a range of differences and perspectives within the audience groups. The research focused on exploring information needs, priorities, and concerns in the context of everyday lives using informal, open-ended, face-to-face discussions with a loosely structured protocol.

Participants were selected to ensure that a range of demographic characteristics within each of the specified target groups was covered. The sample was not intended to be a representative sample of each of the target populations but representative of the diversity of user needs. Choosing on this basis maximises the usefulness of data derived from small samples. The interview protocols for designers, builders and their clients had a common structure:

- Understandings: exploring what people understood a sustainable building to be and how much information they had about it.
- Information sources: explored the range and usefulness of information sources that the participants had used themselves.
- Evaluating specific sources: asked participants to evaluate information sources.
- Future possibilities: This section explored potentially useful solutions to information provision from within the participant's framework and everyday context of use.

The research yielded a clear understanding of the information needs (subject matter, language set and preferred media sources) of the audience. This provided the basis for design, content selection, writing style, media selection and presentation of the final product.

CONTENT AND MEDIA SELECTION

Research indicated the need for different media to be used to communicate to different sub groups of each target audience. By developing communication formats that were similar to the audiences existing communication forms, the Your Home materials could replace or supplement those in use. The primary media form chosen for each audience were: (a) for consumers, a magazine style full colour glossy printed guide; (b) for builder and designers, a printed ring bound folder of individual factsheets; and (c) for students, web and CD based electronic forms. Additional printed promotional materials were developed for achieving widespread promotion while reducing cost and waste.

Most consumer pre-purchase research is via glossy magazines, consumer fairs and display villages. The Your Home consumer guide was developed as a glossy magazine to be distributed at a range of outlets where consumers undertake pre-purchase research. To achieve adequate market penetration, a format suitable for high volume, low cost was chosen. When their awareness of the issues and benefits is raised, consumers often require the more detailed information, often sourced as required throughout the course of the project. To meet this need, the entire Your Home Technical Manual is included on CD ROM in the back of the magazine. This has the added advantage of keeping the two distinct levels of information separate, avoiding information overload in the first instance.

It was observed that designers and builders were reluctant to access internet or other electronic sources in their work practice, with their preferred media form being the printed manual. The Your Home Technical Manual factsheet format was designed to meet the audience need for readily available small parcels of information. The Manual consists of an oversized loose leaf folder designed to allow practitioners to leave it open on the workspace, remove pages for photocopying, and to file additional information they collect to supplement the materials.

Varying levels of expertise and understanding within each audience group dictated that the information should be presented to each group in varying levels of technical detail. It was decided that two main levels of information would be developed - each with a dual purpose:

- The Consumer Guide introduces concepts of good design to potential home buyers and renovators in terms of comfort, lifestyle, health, economy and safety. The environmental sustainability messages are inconspicuous and incorporated into the simple good design practice messages, giving a sense that environmental sustainability is normal practice.
- The Technical Manual comprises some 70 fact sheets, written in an easy to understand non-technical language, explaining the concept and possible solutions to the full range of environmental impacts. Where possible practical demonstrations of existing solutions are presented to reinforce the message that environmentally sustainable solutions are normal practice. A number of case studies of existing houses in different climate zones were provided as examples of excellence.

The Technical Manual was also designed to satisfy motivated designers with sound working knowledge in specific fields. For this audience each issue specific factsheet lists additional reference materials and supporting organisations.

The computer literate audience was identified as quickly growing and becoming influential so all consumer and technical materials were reproduced on the world wide web in html format with printable factsheets in pdf format, and all available free of charge.

PROMOTION AND APPLICATION

By far the most critical pre-requisite for success in terms of mainstreaming is the distribution and promotion of Your Home guide materials. Perceived ownership of the materials by the various industry, government and community agencies involved in their development has aided enormously in this regard.

The distribution strategy was divided into three key goals:

- To provide the next generation of builders and designers with the knowledge and tools to incorporate environmentally sensitive actions as a matter of normal design practice;
- To update all existing builders and designers with the knowledge and the tools to incorporate environmentally sensitive actions as a matter of normal design practice;
- To help increase the market for environmentally sustainable homes by providing consumer materials to those interested in building or renovating a home, at a location and at a time when design choices and material selection is taking place.

To satisfy these goals a sophisticated communication action plan has been established. The following is a list of key elements from the communication action plan:

- The CD form of the materials has been provided to tertiary educational institutions at no cost, with the majority of university and technical education institutions adopting Your Home materials as a required reference in design and building related courses.
- National professional development training programs based on Your Home materials are being delivered to members of most industry representative organisations covering builders and building designers.
- Consumer guide materials are provided to builders and designers for use during consultations with their clients.
- City Councils and Local Governments provide Your Home brochures at the counter and distributing it to consumers, designers and builders inquiring about building approval.
- The Your Home materials are promoted and distributed at display home villages, home shows, trade shows, community fairs and conferences in addition to many other outlets where design choices and material selection is taking place.
- The Your Home materials are distributed in conjunction with related government promotional activities and subsidy programs.
- The Technical Manual is available for retail at many building industry bookshops.
- Special events such as high profile public lectures and home tours are held to promote the materials.
- Regionally relevant case studies from the Your Home Technical Manual are promoted in popular newspaper and magazine media.
- The Your Home website is hot-linked to numerous industry, corporate and community sites related to house design and construction.

CONCLUSION

Whilst Your Home has not been in the market for a sufficient period of time to warrant a full evaluation, feedback from stakeholders and practitioners already using it is overwhelmingly positive. It is anticipated that Your Home will play a major role in mainstreaming more sustainable residential design and construction practices throughout Australia in coming years.

A full evaluation will be conducted at the end of the first year of operation and further developments made where required. The materials are subject to periodical improvements firstly through the electronic media forms and later through reprints. Negotiations are currently under way to create an industry body to take greater responsibility for ownership of Your Home from the Australian Government to further develop, promote and distribute the resource.

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Negotiating a Green Mindset

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1. INTRODUCTION

Sustainable design, construction and operations rely on appropriate technologies, materials and systems. However, the primary barrier to integration or implementation is none of the above, but rather the mindset of the many stakeholders who drive the decisions during the design and construction process.

The non-technical barriers to transforming current practice include, misconceptions about cost, short term thinking, assumed liability risks, externalities, valuation, the threat of new or different processes or anything that is perceived to challenge 'business as usual'. The direct links between health and natural resource devastation and design/construction decisions are completely unknown to most of the population, including property owners, lenders, designers and developers.

Being knowledgeable and aware of these issues is important, but will not usually be enough to convince a client, designer, contractor, regulator, or anyone else of their value or merit.

What are the skills that can help an advocate for sustainability be successful in incorporating sustainable strategies, technologies or criteria? Who needs to be involved in the dialogue? How do you identify important stakeholders? How can you best prepare yourself to meet the extra challenges that sustainable efforts can bring? What will prepare you to take a leadership role if needed? How can you open doors to possibility in the minds of team members? Can you guide a focus towards optimizing performance criteria rather than micro-managing risk?

The Green Roundtable (GRT) is an organization that promotes the mainstreaming of sustainable principles into design and construction through programs in education, policy reform and technical assistance. GRT's clients include developers, institutions, universities, insurers, government agencies, designers and others, all of who struggle with the conflicts and obstacles posed by differences in mindset. The ability to "negotiate a green mindset" has been critical to the success of the GRT in working with these clients as well as in thriving as an organization. In an effort to empower change agents, The GRT has distilled these skills into an interactive workshop that provides the opportunity to engage participants in active exercises that allow for discovery and internalization of these crucial skills, and the response from participants has been overwhelmingly positive.

The Negotiating Table provides negotiation and conflict management training to corporations, government agencies, nonprofit organizations and individuals. It has applied these skills to

the design and construction sectors and has been working with GRT to specifically apply those skills to issues relating to green design.

2. THE MINDSET PROBLEM

Mindset issues plague any introduction of sustainable design concepts to the market. They are like a mine field, pervasive yet sometimes difficult to detect. One encounters them in all phases of design and construction and from every party involved in the party. From choosing a site, to valuing the project, to obtaining insurance, and so on down the line, the people involved in creating the built environment bring their preconceived judgments and misperceptions to the process. These preconceived notions then influence the decisions they make and the factors they consider in making those decisions.

For example, architects and building owners frequently consider only the initial cost of systems and materials they select for their projects rather than looking long term life cycle costs. They might select less expensive and less efficient windows without considering that they will end up spending more on heating the building in the long term.

More insidiously, by choosing to rely on traditional infrastructure systems such as storm water or waste water, owners may increase their capital costs and definitely increase the cost to the community of maintaining and operating inefficient systems. The widespread use of impervious pavement short circuits the natural system's ability to replenish ground water, thereby reducing water quantity, quality, and raising the cost of water to consumers. In addition, the runoff gets diverted to energy-intensive treatment plants, which end up needlessly processing clean water that inadvertently infiltrates the storm water infrastructure through negative pressure

These are just examples. This paper focuses not on the technicalities of all of the long term issues but instead on the fact that people are unaware of them and are resistant to considering them during the design and construction process. Even when presented with facts and figures that indicate the cost and environmental effectiveness of sustainable concepts and systems, many people reject them due to unsubstantiated fears, negative past experiences, and an unwillingness to change from existing, known practices. People have a distaste for uncertainty and find ways of justifying their continued use of inefficient practices.

The limitations and barriers created through this resistance show up in market demand and are embedded in policies and regulations. For example, legislation in some of the United States requires that contracts be awarded to the lowest bidder only, setting up an incentive for short term savings at long term expense. More importantly, this process requires the design to be completed before going out to bid, therefore excluding contractors from adding valuable insights through participation in the design process.

In addition, the design professions and other industry sectors relating to the built environment each have their own, unique mindset barriers that further limit and complicate the introduction of sustainable strategies. For example, the way engineers in the United States are contracted and compensated, as well as their tremendous sensitivity to liability concerns, promotes conservative decision making on their part and limits their willingness to introduce creative or alternative solutions to design problems.

Barriers manifest themselves in three ways. Sometimes people reject ideas of sustainability outright. At other times, they appear hesitant yet friendly, but may struggle with their own

inertia and end up excluding green systems and ideas from their projects. Finally, some people express lip service to sustainable concepts, but when you look closely at their work, you find out that they incorporated very little in practice, claiming that they did all that was possible under the circumstances.

As a result, sustainable design concepts are often neglected, rejected, or pared out of building projects. This fact creates environmental problems, increases the long-term costs of the projects, and inflicts long-lasting damage on the environment, the economy, and society in general.

Green design professionals and advocates of sustainability are often frustrated with these barriers and have had only mixed success overcoming them. They try repeatedly to promote their ideas, present credible and cogent facts and figures to substantiate their claims, and are rebuffed by the forces of ignorance, greed, short-term thinking, and resistance to change. We next examine a framework designed to help people understand and overcome barriers such as these and apply this framework to the green mindset problem.

3. A NEGOTIATING FRAMEWORK

Over the past two decades, following the pioneering work of Roger Fisher and Bill Ury (1981)at the Harvard Program on Negotiations, the fundamental notions of negotiation have shifted away from traditional bargaining game theory to an interest-based, mutual gains approach. Prior to this work, negotiation was viewed as a tactical process in which opponents tricked each other to gain advantages and ultimately secure a win at the expense of the other party. The interest-based approach turned all that on its head. Rather than focusing on trying to persuade the other party by advancing arguments and employing tactics, this approach advocated that understanding the interests of the other party and trying to satisfy those while simultaneously satisfying your own was a more effective method of reaching meaningful and mutually beneficial agreements.

To make application of this approach more practical for implementation, Fisher and Ertel (1995) distilled the negotiation process into seven elements that need to be addressed in order to arrive at a mutually beneficial, interest-based outcome. These elements are illustrated in Figure 1.

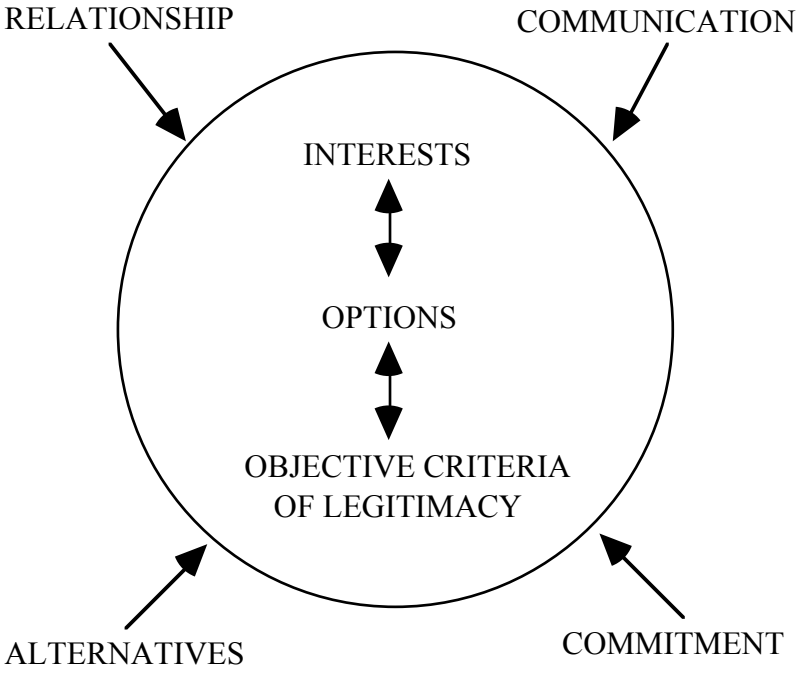

Figure 1 The seven elements of mutual gains negotiation.

A description of each of the elements follows.

3.1 Interests

Employing this approach, interests therefore replace tactics as the focus of the negotiator. Instead of trying to persuade or convince the other party that you are right or that what they wish to do is harmful, seek to understand them and their needs.

This is particularly valuable when you encounter resistance to your ideas. When you wish to promote an idea such as Green Design, the first impulse that you might have is to explain the benefits of your idea to the other person. Consider how often this may have happened to you. You know you are presenting something of value, and yet, the other person is not receptive, or may even be hostile to what you have to say.

A natural first reaction is to explain your idea again, perhaps using different words, appealing to the common sense of the other person. And yet they continue to resist. Another natural reaction is to get defensive and angry regarding their attitude. You might discount them as boorish, irresponsible, thick-headed, or greedy. No matter how hard you try, they refuse to hear the very simple and sensible things you are suggesting.

The alternative approach we suggest is to focus on understanding them and their interests. Start the discussion with an exploration of what they are looking to get from the project, their concerns and their fears. Listen attentively to what they say and see if you can paraphrase what you have heard. The focus of your efforts should be to encourage them to discuss their interests with you with the goal of understanding them, not refuting them. When the time

comes for you to present your ideas, it is still likely that you will encounter resistance, however rather than reacting to that resistance with dismay, use it as an opportunity to learn even more about the other party's needs and concerns. In fact, use every opportunity to learn more of their interests during the negotiation.

You also need to understand your own interests in the process, particularly if you are part of a team or represent others. Who are the stakeholders on your side of the table and what do they want, professionally and personally from the negotiation. What do you want, and most importantly, why do you want what you say you want. Base your goals in the negotiation on your interests.

3.2 Relationship

One of the primary interests you should nurture during the negotiation is the relationship between the two of you during the negotiation. Relationships are always important in negotiations, sometimes more than others, and particularly if you expect to be dealing with the other party over a longer period of time following the negotiations. Avoid taking actions that damage the relationship, such as unilateral moves, tactical surprises, and distortions of the truth. Assess the relationship that you have currently, determine what type of relationship you would like to have, and make yourself the goal of building the relationship in the direction you would like it to go.

3.3 Communication

Communication skills are fundamental to negotiation. These are the skills that allow you to inquire about interests, listen for the responses, and formulate your counter-responses. Try to keep a balance of inquiry about the other party and advocacy for your own interests. In general, people over-emphasize advocacy at the expense of inquiry. Suspend your judgment of the other party when they speak and try to understand them without prior assumptions, even if you do not agree with what they have to say. Finally, avoid sending damaging messages to the other party by word or deed. Make your messages deliberate, and ensure that they do not harm the relationship between you and the other party.

3.4 Options

Once you have explored the interests of the other party and have revealed your own, you can start by exploring the options that they have brought to the table regarding solutions and present your options for their consideration. The important thing is not to dismiss their options or advocate too strongly for your own, but to consider all of the options that are on the table as possible building blocks for an eventual resolution. Try as much as possible to separate option generation from option evaluation during this process.

If they advocate strongly for their position, use it as an opportunity to find out why this position meets their interests particularly well. If they reject your options, find out what interests of their are not met by the option or what other interests need to be considered for a workable solution. In short, use every opportunity to explore interests with the other party.

3.5 Objective Criteria of Legitimacy

Another approach to options is to examine them in light of objective criteria. This applies to both the options you present to them and the ones you hear from them during the negotiation. Whenever anyone states a position or offers an option, one thing that you should do is to ask them and yourself about the objective criteria that support or undermine the option under consideration.

Similarly, do not present an argument unless you have objective criteria by which to support it. You do not the negotiation to become an irrational argument between you and the other party. Remember that to be effective, the objective criteria you select to support your views must be truly objective in the sense that they come from third party sources that are respected by both parties. The objective criteria should be persuasive to the other party rather than to you - you are already convinced of your views.

3.6 Commitment

As you approach a level of understanding with the other party on both of your sets of interests and on workable options, you need to start moving toward an agreement that both of you will carry out. Commitments are built up slowly over time (Cialdini 1984), and you may need to take small steps in achieving the mutual understandings that you are seeking. Make sure you and the other party understand what has been agreed to between you. Do not be afraid to ask the hard questions. Finally, make sure to outline the steps you both need to take to ensure that what you have agreed to will be implemented.

3.7 Alternatives

As you negotiate, be aware what you will do if the other party and you can not reach an agreement. What are your possible alternatives to a negotiated agreement, and of those, which is your best. Try to understand what the other party's alternatives are as well, since that will determine how they will act during the negotiation. Your alternatives determine when you decide to stay in a negotiation and when you choose to walk away. It is therefore critical to understand to the best of your abilities the alternatives of both sides.

4. NEGOTIATING A GREEN MINDSET

How then do you apply this approach to negotiating a green mindset?

To begin with, focus on understanding the other party, be they contractor, owner, or engineer, with emphasis on their interest. What is really driving them, beyond your assumptions? Inquire to find out, and hold off on expounding your ideas. Strive to communicate with them and build a relationship that is conducive to the sharing of ideas and concerns.

When you present your 'green' ideas, use objective criteria that are persuasive to them. When you encounter their inevitable resistance to your ideas, use the opportunity to understand their interests even better. Discuss multiple options with them, and explore the alternatives that each of you will go to if you can not reach an agreement on the issues.

Finally, build commitments slowly. As a first step, be satisfied with getting them to share their concerns with you. If they are then willing to hear what you have to say, you have stepped up the commitment one step forward. If they are then willing to engage you in a discussion of objective criteria, that is again another step toward commitment. Thus, slowly, over time, you can create both a relationship and a commitment to mutually beneficial solutions that take into account your 'green' concerns as well as the other party's needs and fears.

5. CONCLUSION

It is difficult to contend with the often stubborn resistance to environmentally and economically sound ideas that you encounter in your work. Using the approach of mutual

gains negotiation and focusing on interests, it is possible to overcome this resistance and to negotiate outcomes that take into account the needs and desires of both parties.

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Successful Strategies for Market Transformation

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1. INTRODUCTION

Many people who care about sustainable design express a desire to change the way the built environment is created through a process of market transformation. This paper examines some of the key questions regarding market transformation and suggests strategies for its successful implementation.

Market transformation requires a broad vision and a comprehensive approach. Sustainability is not comprised of a set of isolated, independent principles. Instead, the roots of sustainable concepts are intertwined and interdependent, and the *Ability* to *Sustain* is dependent on the interrelationships rather than on discreet elements**.**

To be effective catalysts for change, the strategies used to approach the existing conditions must therefore also be systematic and holistic in nature. It is important to recognize the links between concepts, fields and professions in order to facilitate the steps needed to create momentum and inspire change. To be successful, the approach needs to be proactive, based an understanding of specific interests, threats and opportunities, and capable of optimizing mutual benefits, creating long-term value, and motivating and inspiring stakeholders.

In planning a strategy for market transformation, there are many questions to consider. First, how will you know what is effective? How will you set your goals and measure your success? What is the 'market' you are trying to transform and why is market transformation necessary? Finally, what would a transformed market look like? It is critical to invest up-front time to address these questions so you can set ambitious, realistic goals based on a solid understanding of the market.

Next, consider the process you are about to undertake. What would the process look like to move towards transformation? What is your role in that process, or what would you like it to be? What are the forces at play in the market, and where are leverage points through which you can effect change? What is the 'big picture' and how do you fit into it? How can you create opportunity where others don't recognize it? How can you transform negativity into possibility?

Of course, the process is not static. You need to tailor your approach to engage the interests of particular parties while maintaining a consistent mission and vision. You should strive to be a change agent to effect change directly as well as a capacity builder to help others internalize the changes and continue implementing them. For that, you must inspire the leadership that is necessary to institute change. You should also strive to capitalize on latent human resources to increase your leverage.

Finally, to be effective, you need to understand how politics, design, education, civics, industry and business combine in an overall strategy to weave a tapestry of change. Using our work in Massachusetts as an example, we will show how to optimize opportunities, open the door to possibilities and create a momentum in your community that is self-generating and self-sustaining.

2. THE MARKET

Before you transform the market, you have to think about what it is that you are trying to transform. What is the "market" as you define it? What are the forces at play? How do you determine the scope of and relationships between the industries that shape the built environment? Often we define the market too narrowly, neglecting to consider more peripheral players who at times play a critical role in determining the course of the market.

The built environment is created not only by designers and contractors, but also by the financing organizations that provide the funding for development, the insurance companies that underwrite professional liabiliy as well as the development and subsequent operation of the buildings, and many other entities. These include government and regulatory bodies, building owners, the ultimate users, facilities managers, transportation and infrastructure, and many others. In defining the market we intend to transform, we need to not only consider a broad range of players, but to take a bird's eye view and understand the complex interrelationships between them. Only by defining the market in broad, holistic terms can we then consider how to transform the way it functions.

3. THE MARKET TRANSFORMATION PROCESS

Next, we turn our attention to market transformation: How does it happen, what motivates it? What is the nature of systems based, holistic strategies for market transformation? How do issues of scale affect market transformation? How do different stakeholders take a leadership role in transforming the market (e.g. government agencies, industry leaders, nonprofit organizations, public-private partnerships, finance and insurance sectors)? How can you position your self or your organization in the role of leader, risk-taker, participant, etc?

As change agents, you are bound to encounter mindset barriers as you introduce new concepts and ideas to skeptical audiences. You need to recognize the barriers you encounter, and negotiate the negative reactions that arise when you introduce new ideas to the market. You need to speak to and engage different sectors of the market from their own context, own vocabulary, and own time scale.

One effective tool that you can use to analyze the market is called a force diagram. This diagram consists of a vertical line symbolizing the current state of the market and arrows pointing at this line from left and right, symbolizing the forces acting to keep the market at equilibrium in its present state. You need to assess the current state of the market and to understand the forces acting on the market and the balance between them. In order to move the market, you need to either strengthen the forces that encourage the changes you want or weaken the barriers that prevent them from happening. The positive forces most readily strengthened or the negative forces most easily weakened become the leverage points that can promote market transformation.

Much of your work will involve communication and outreach. You must create opportunities for dialog and ensure that you communicate sufficiently and effectively with all the relevant stakeholders. In order to accomplish this, it helps to draw a stakeholder map that encompasses

all of the decision makers in the process, as well as those who can influence the process or will be affected by the decisions made. It is most critical to identify those people on the sidelines who are not direct decision-makers, but can step in to either promote your changes or block them. Take a systems approach and look for links, try to make ripples.

Using your understanding of the stakeholders and the forces involved, you can then analyze the barriers and opportunities in each of the stakeholders' industries. Specifically, you can identify what other associated industry-specific issues affect the process. You must then look for and find allies at key leverage positions and develop strategic partnerships with others who can help you move the process forward. Finally, you must develop a strategic plan and secure resources on a realistic timeline. Taking the time to create a plan in advance will make you more likely to succeed in the transformation you are trying to effect.

4. CRITICAL SKILLS FOR CHANGE AGENTS

Once you know who you need to be talking to, practice your communication skills. Communicate more frequently than you otherwise would, partly by advocating the views you care about, but mostly by asking people open-minded questions and listening to their interests. Negotiation is all about finding out the other parties' interests and creating options for mutual gains based on those interests. Constantly question your desired outcome (to merely maintain? sustain? or regenerate?) Open the possibilities for others. Connect dots for people. Redundancy is good, and nothing is too obvious. There can NEVER be too much communication.

Timing is also crucial. Every effort you undertake takes place in a context. You must ensure that your initiative takes into account crucial legislative cycles, events, and other key factors. If decisions get made based on a fiscal year, for instance, you need to be aware of that constraint and concentrate your efforts at times when they are most likely to get incorporated in the following year's plans. Put leverage into multiple points in the system - if one point fails, or falls stagnant, there is always movement somewhere else. You also need to invest in marketing in order to get out the message to the market on what you are doing.

In addition, you must leverage one opportunity off of another. For example, if you have made progress getting a bank to buy into a change process, you should then look to insurance companies and property owners, as well as facility managers and designers to sign on to similar changes as the bank agreed to. Look for spirals of causal relationships. Finally, you will be most successful if you position yourself so you have little to lose by trying. Since your risk is minimized, it will not limit you or force you to compromise the position you're in.

On a personal level, be generous, have integrity, and be honest Be PASSIONATE and infect others with your passion. Be proactive in communicating and promoting your issues and NEVER be reactive. Don't be afraid to take on challenges that no one else wants or shy away from trying to change the unchangeable. Be a chameleon – at times be a catalyst, supporter, limit setter, facilitator, or other roles you desire.

By applying these skills, principles and tools, you can become a much more effective communicator and change agent..

5. THE GREEN ROUNDTABLE AS A CASE STUDY

The Green Roundtable, Inc. (GRT) is an independent non-profit organization whose mission is to promote and support healthy, efficient and sustaining development and building projects

through strategic outreach, education, policy advocacy and technical assistance. The GRT strives to mainstream 'green' and ultimately become obsolete. The existing unhealthy, inefficient, and unsustainable development is caused by a lack of systems thinking and coordination among the stakeholders involved in creating it. The GRT therefore uses systems based holistic strategies to proactively create effective programs that reach out across industries, professions, and other boundaries.

Our strategy is to educate people commissioning and operating buildings to define their green requirements and expectations while simultaneously training and supporting design professionals to provide the services that meet these growing needs. Concurrent with these activities, the GRT is active in policy reform that will ultimately require both clients and design professionals to meet the goals of healthy, effective and efficient design and development.

We are active in helping to establish green building standards in many different organizations, agencies and communities. We operate through education, policy change, and technical assistance, with the emphasis on the inerconnections between them. In three years, this organization has put sustainable design on the map in Masachusetts among legislators, educators, state and city agencies, every major design firm, property owners and developers. Within a short time, we have become recognized as the 'go-to' organization for every issue related to sustainable design from energy efficiency to sick building syndrome to environmental justice issues, and have leveraged our central position to help build a cohesive community of previously unrelated entities.

We take a 'systems' approach to everything we do and consciously make an effort to coordinate our activities within each program area because it is the integration and links between education, policy and T/A that make it most effective

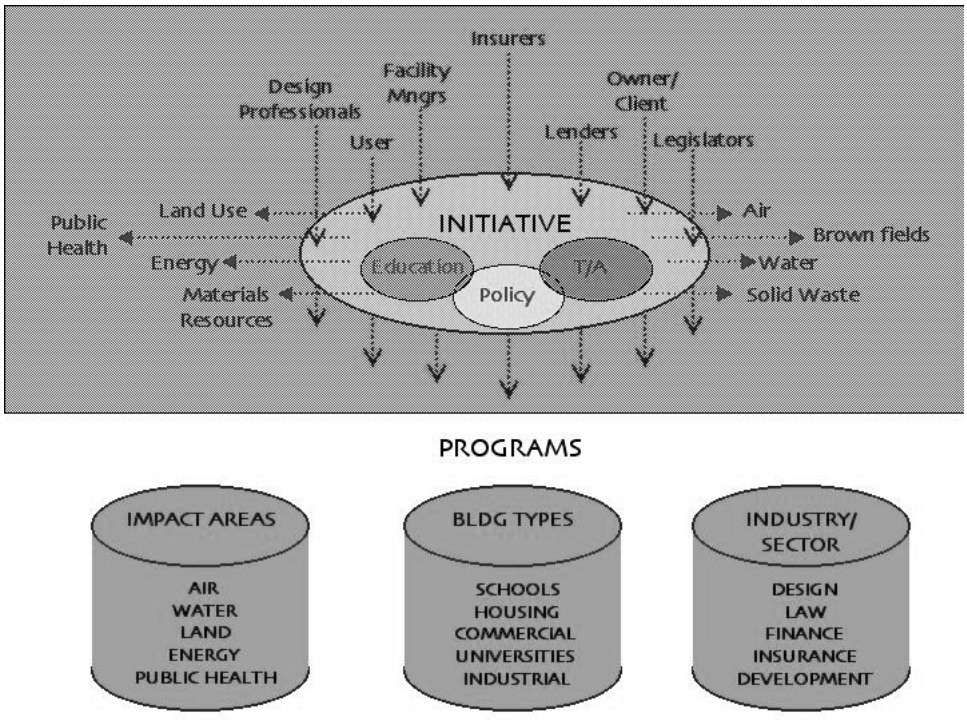

Figure 1 Program structure reflects the built environment

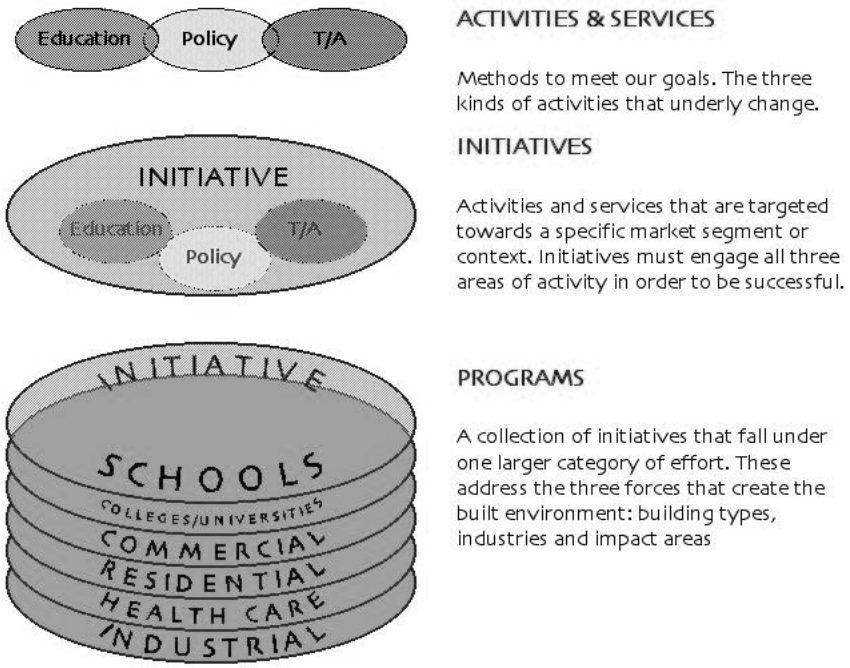

Figure 2 Integrated activities and services

4.1 Education

A few examples of our initiatives in the area of education include:

Architecture Education: The skills and knowledge necessary to create healthy, efficient built environments are not being taught in architecture schools. There is a need to fully integrate concepts of sustainable design into the education of architects in order to transform our built environment.

Boston Architectural Center: GRT assisted in the development of the Green Design Certificate Program (first in the region, one of the few in the country) and further in the development of an internet based equivalent certificate program.

Boot Camp: A combination of education, training and management consulting for design firms is being developed, and is already scheduled for many firms. This allows firms to go beyond the typical education of a few dedicated people, and transform their practice. Not only are staff educated and trained, but management issues that affect the implementation of integrated design are dealt with in the specific context of the firm's unique culture.

Presentations and lectures: Public awareness raising effort for school groups, communities, and through retail establishments (Patagonia lecture series, and more.) 52 this past year presentations and lectures were given in the past year. These are ongoing.

Roundtables: Monthly roundtable series on aspects of design (free and open to general public). Meetings are meant to be a proactive dialogue about topics that relate to diverse stakeholders. Topics include: alternative strategies for storm/sewer management, renewable energy technologies, contract issues to insure high performance, construction and demolition waste recycling, and more. Ongoing.

Specialized Roundtables: Special Roundtable series focuses on helping specific industries overcome their internal barriers. These sector specific meetings are held every few months and include the following groups: developers, engineers, facility managers, lenders,

contractors and one specifically for Green Design Leadership Coordination. These are ongoing.
Public Schools Outreach: Education and outreach for the Mass. Tech. Collaborative / Renewable Energy Trust, and Dept. of Education/SBAP Green Schools Program. Two major day-long workshops have been done, and on-demand education for communities across the Commonwealth is ongoing. Any community that is renovating or designing a new school can request assistance to understand how to incorporate energy efficient, healthy design strategies that integrate renewable energy technologies.

4.2 Policy

A few examples of our initiatives in the area of policy include:

Tax Credit: Co-drafters of a Green Building Tax Credit. GRT helped draft this piece of legislation, presented to legislators to help them understand the value of green building to the Commonwealth, and testified before legislators at the State House in support of the proposed legislation.
School Construction Regulations: GRT has been working with the Healthy Schools Network to draft revised regulations for the Dept. of Education's School Building Assistance Program. The proposed revised reimbursement regulations will address energy efficiency, long term operations and maintenance costs and negative impacts on public health, natural resources and the environment.
Institutional/Municipal Standards: GRT assists in the development of building and operation standards for colleges, universities, municipalities, state agencies and other property owners that impact all building, development and operational practices that they undertake.
Incentive Coordination: GRT convened the first of ongoing meetings to coordinate incentive programs for design and construction. Participants included utilities, state agencies, Trusts and private foundations. This meeting was meant to identify areas of mutual coordination, find areas lacking in incentives that could be addressed and discuss better implementation efforts to encourage their use.

4.3 Technical Assistance

GRT provides consulting and review to a variety of public and private sector clients on building systems, integration, process and implementation as well as contract review, peer review, specifications and strategic planning. These clients include Harvard University, State of Massachusetts, AES Enterprises, various architectural firms (for their clients), American Youth Foundation and various public schools. Research about technologies, systems, case studies and more is ongoing. Fee for service and contract work has been the financial mainstay of the organization, funding programs.

The key to all of these efforts is the integration between them and the leveraging of knowledge and progress from one to the other.

5. CONCLUSION

It is impossible to know scientifically which forces and actions will bring about market transformation. There are too many variables, and too many unknown and unanticipated occurences that are not controlled by any one entity. However, if one approaches the issue of sustainability in the built environment with a deep awareness of systems, and the interdependence of the forces of nature, economy, commerce, social and human nature, one can begin to perceive opportunities that might otherwise be missed without a broad perspective. An emphasis on high leverage efforts, mutual gains and an interconnected,

holistic approach is therefore likely to be the most effective approach to market transformation.

Recycling of Construction Waste – Barriers to Success

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1. INTRODUCTION

Waste represents an enormous loss of resources both in the form of materials and energy. Indeed, quantities of waste can be seen as an indicator of the material efficiency of society. The challenge facing those concerned with the reduction of construction waste is to move from landfill-dominant waste management towards recycling-intensive solutions and ultimately a reduction in waste generation. The UK government paper *A Way with Waste* [(1)] sets targets for increasing recycling rates from 8% to in excess of 30%. This implies a four-fold increase in current markets. If we are to achieve these targets new products incorporating recycled materials, new processes, new markets and new specifications are needed. For some construction materials, markets do currently exist, namely metals and aggregates. The level to which other construction materials (plastics, timber, glass etc.) can be re-used or recycled is highly dependent on the existence of market barriers and policy issues that tend to constrain market potential.

Construction waste materials contain components capable of high-grade uses, but there are a number of barriers that prevent maximum efficiency of reuse and recycling. Some of these barriers relate to specific materials and some are of a more general nature. By assessing construction waste in detail, a benchmark can be established from which improvements can be measured. Focusing on current recycling and reuse practices in Greater Nottingham and using detailed construction waste data established as part of the research project, this paper aims to highlight the barriers to the successful reuse and recycling of construction waste.

The information provided throughout this paper has been derived from a wider study that aims to present a *demonstration project to increase the use of recycled resources in construction: a case study of Greater Nottingham* in the United Kingdom. Further details of the work can be found at http://construction.ntu.ac.uk/building/research/detr_nottingham.asp [(2)] . The fluid nature of the industry is reflected by the significant changes in the operation of the landfill and transfer sites over the three-year survey period. During this time, the ownership of several landfill sites has changed, a new transfer station has been opened and one landfill site has ceased taking construction waste.

2. CONSTRUCTION WASTE SURVEY

The data presented here represents an analysis of the construction waste arising between 1999 and 2001. The data was compiled from surveys and weighbridge returns provided by

all the landfill sites and construction waste recycling centre operators in the Greater Nottingham Region. The survey comprised of three parts:

i) detailed small load survey
ii) detailed large load survey
iii) weighbridge ticket survey

The data for small load skips was obtained by hand picking through the contents of construction skips of less than 4 tonnes delivered to landfill sites. The surveyed skips were selected randomly using a statistically valid model and the contents separated into predetermined categories of material and then weighed. In total, in excess of 50 skips were surveyed over a nine-day period each year.

For the large loads, the estimation of individual material content of the skips was facilitated by the use of video evidence of the tipping and sorting process as undertaken by recycling centre personnel. The use of this method was necessitated due to health and safety requirements, and the logistic and economic impracticalities of hand sorting through skips containing in excess of 4 tonnes of waste. To ensure the statistical validity of this survey, a total of 30 mixed load skips were surveyed over a one-day period in 2001.

2.1 construction waste survey results

Table 1 shows the results of the detailed survey. The contents of each small load skip was separated into predetermined categories of material and then weighed also included here is the data from the detailed video survey carried out on bulk loads in 2001.

In order to differentiate between inert and non-inert waste the data has been sub-divided into two respective sub-groups. Table 1 expresses the percentage of individual material arising relative to the weight of the total construction waste surveyed per day. On average, in 2001, 66 tonnes of large load construction waste was surveyed per day, compared with around 15 tonnes, 20 tonnes and 15 tonnes per day in 1999, 2000 and 2001 respectively for the small load, handpicked surveys.

For this paper, soil and cover have been removed from the construction waste arising data (unless specifically stated otherwise), so that it is in line with previous reports and European Convention [(3)].

The reporting of construction waste data by landfill operators and construction recycling centres contains ambiguities specifically in the way that waste is categorised. Many of the materials fall under the same classification and a more specific standard classification of construction waste is required to enable a more detailed analysis to be carried out. This is a major problem that currently exists in the UK and effectively means that surveys of reported weighbridge data are only as good as the least detailed information set. The detailed small and large load survey, conducted as part of this research, offers the detail necessary to fully analyse the potential for the recycling or re-use of construction waste.

The level of detail obtainable from the weighbridge ticket survey is shown in Figure 1, where a graphic representation of the waste profile for Greater Nottingham is shown. The figure shows that there has been a steady growth in the quantity of material going to

landfill over the period of the survey, with the total amount of waste rising by approximately 24%. The figure also shows that the amount of construction waste recorded has risen by approximately 15% over the same period and, consequently, there has been a reduction in construction waste relative to other wastes going to landfill. The proportion of construction waste as a percentage of all waste arising at landfill has fallen by 5.1% over the last year. In the context of increased construction activity over the last three years in the Greater Nottingham region, this reduction can partly be attributed to the impact of the transfer stations. This research has shown that approximately 70% of all construction waste enters the waste stream via a transfer station. The quantity of material passing through transfer stations has increased significantly over the survey period, with an 11% growth

Table 1 Summary of hand picked and bulk survey results, 1999-2001

Material	**Hand-picked survey 1999 % of total waste**	**Hand-picked survey 2000 % of total waste**	**Hand-picked survey 2001 % of total waste**	**Bulk survey 2001 % of total waste**	**Average % of total waste for all detailed surveys**
Inert materials					
Blocks-concrete	5.32	5.74	12.41	3.17	6.66
Bricks-commons	6.20	3.97	1.50	14.35	6.50
Bricks-engineering	1.55	0.55	0.66	0.66	0.86
Bricks-facing	1.49	1.22	1.61	1.56	1.47
Cement	-	0.23	-	-	0.06
Ceramic Tiles	2.68	0.27	1.78	0.39	1.28
Clay drains	-	0.00	-	-	0.00
Concrete	6.44	7.09	8.71	6.81	7.06
Plaster	-	0.19	0.09	-	0.07
Roof tiles	5.25	0.77	0.73	-	1.69
Rubble/Hardcore	24.5	28.55	38.1	29.07	30.06
Sand	1.41	3.57	1.88	0.64	1.87
Stone	-	0.36	-	-	0.09
TOTALS (%)	**54.82**	**53.84**	**67.56**	**56.65**	**58.25**
Non-inert materials					
Asbestos	0.03	-	0.00	-	0.01
Brick banding	0.02	0.01	0.00	0.05	0.02
Cabling	0.28	0.15	0.49	0.31	0.31
Carpet	0.30	0.69	1.12	0.08	0.55
Fibreglass	0.15	0.15	0.20	0.56	0.27
Glass	0.01	0.56	1.17	0.39	0.53
Metal-Ferrous	4.16	2.82	6.60	8.76	5.57
Metal-Non ferrous	0.20	0.00	0.27	0.08	0.12
Miscellaneous	4.26	19.48	5.40	8.48	9.40
Paper/Cardboard	3.04	0.28	1.25	1.09	1.41
Plasterboard	4.20	0.94	1.66	0.40	1.8
Plastic	1.28	1.69	0.66	1.40	1.26
Polystyrene	0.04	0.00	0.05	0.20	0.07
PVC Piping	0.03	0.05	0.27	1.93	0.57
Roofing felt	0.30	0.30	0.02	2.61	0.81
Tarmac/Asphalt	2.42	0.36	2.15	0.47	1.35
Timber	14.91	11.96	8.80	14.10	12.44
Vegetation	9.55	6.71	2.35	2.42	5.26

TOTALS (%)	**45.18**	**46.15**	**32.44**	**43.32**	**41.75**

between 1999 and 2000 and a 24%[3] growth between 2000 and 2001. It should be noted that transfer stations dealing specifically with construction waste have only been in operation in Greater Nottingham since 1996.

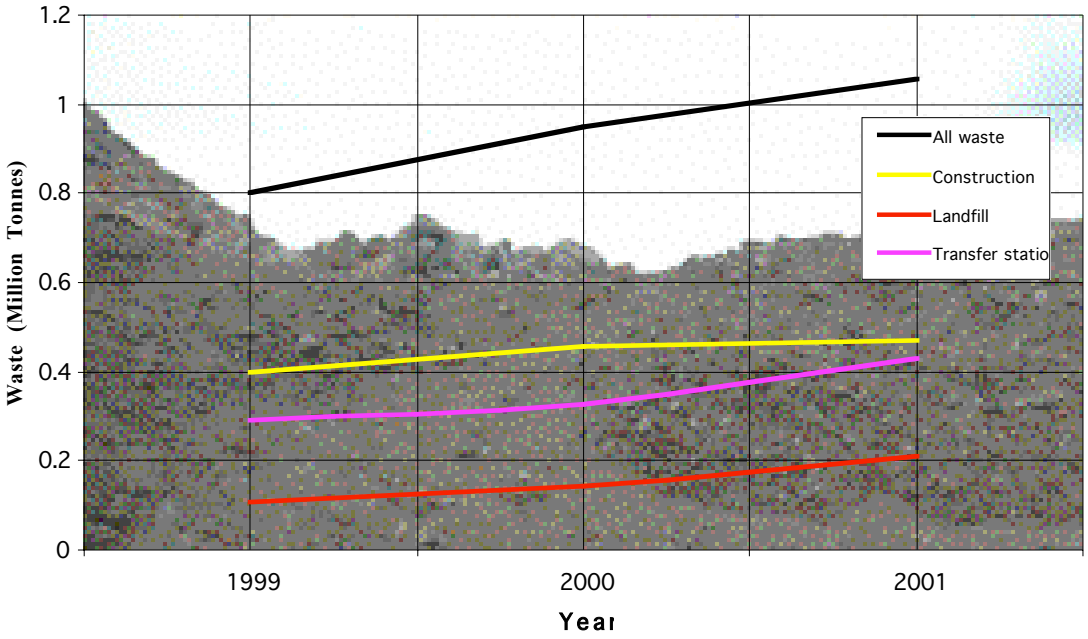

Figure 2 Annual waste arising in tonnes for waste categories surveyed

The figures represented in Figure 1 are indicative of the regional trend and this data has been checked against data provided by the Environment Agency. Over the period April 1999 to September 2001, the data was within ±1.5% of the data provided by the Environmental Agency. This close correlation gives credence to the data set and underpins the findings of the small load surveys.

3. BARRIERS TO THE RE-USE AND RECOVERY OF CONSTRUCTION WASTE

The information presented in Section 2 highlights that significant quantities of construction waste are still going to landfill. Currently, it is clear that the economic potential of construction waste arising in the United Kingdom is not being fully recognised or maximised. Advances need to be made in creating and improving markets for recycled construction materials and a greater effort needs to be made by all those involved in the industry to overcome the barriers that currently exist. The success of this will ultimately determine the amount of material that can be recycled economically.

[3] The figure quoted includes material arising from a recently opened transfer station set up to specifically recycle inert materials which, at the time of the survey, consisted only of soil.

To overcome the current barriers to the re-use of construction materials, a number of issues need to be addressed and, although it may generally be stated that no single measure to minimise construction waste will work on its own, a combination of measures will be required. These include command-and-control regulation, fiscal pressure, education, raised awareness and a social culture of encouragement. Examples of all these issues were found to exist within the Greater Nottingham Area.

Fiscal measures such as taxes can make a crucial difference. Although taxes on landfilling and on primary aggregates have been shown to be effective in diverting construction waste away from landfill, on their own they are an insufficient deterrent.

The introduction of the landfill tax in 1996 provided the catalyst for change. Before this, the majority of construction waste went directly to landfill. Throughout the period of this research, there has been a continued growth in the capacity and the number of transfer stations within the Greater Nottingham region. There are currently five transfer stations handling construction waste within this region. There have also been some changes in the way contractors and/or landfill site operators/recycling centres handle construction waste and this has reduced the amount of such waste going to landfill. However, since its introduction, the significance of the landfill tax has diminished and the effect of the more recent increases in tax is not as apparent, with its effect masked by reduced tipping costs and a more competitive market for landfill materials [(4)].

In the absence of statutory regulations, it is primarily economic considerations that decide whether construction waste is recycled or not. Recycling takes time and investment, and must be attractive both to the recycler and to the end user who may use it as a substitute for primary materials. Proof of a material's viability in terms of cost of conversion or resale is essential in developing a market for the product. However, externalities, such as environmental and social costs must also be reflected in the overall viability of a product. The overall cost of segregation and recovery relative to existing markets is currently the main barrier to recycling construction materials. The transfer station operators within the region are continually looking for new ways to maximise the potential of construction waste. In all cases, this is done in isolation. The sector would benefit from better communication between all those involved in the process of producing and recycling construction waste. There is also an absence of local government initiatives specifically targeting the construction sector. Commercial opportunities exist for a facilitator to bring together all parties to make best use of the vast quantities of construction waste arising. Joint public and private sector initiatives will be needed to develop appropriate markets for recycled/recyclable materials and producers must consistently and competitively develop market specifications for these materials. The reclamation and recycling of construction materials requires initial investment and/or a continuing application of resources (time, space, labour, plant). The incentive to bring about change will only arise if the costs of these prove to be less than the combined value of materials wasted and the cost of their disposal. Currently, the majority of construction waste that is recycled has a very low end use value.

The potential for recycled building materials to be contaminated by a wide range of substances/materials causes many problems. Reliable definitions of levels of specification and performance are needed for recycled materials on a fitness-for-purpose basis. A local

centralised recycling facility to process construction materials would enable demand to be satisfied from a single source and would permit valuable and essential product quality testing. Demonstrations of acceptability and quality systems are useful in promoting the use of waste materials and a need exists for promotional literature, with technical backup, explaining the product's performance. A local centralised agency collecting and analysing data on recycling would help to direct these efforts, as would a coding system for each item, making it easier to identify appropriate recycling processes. Contractors would also benefit from promotional videos/CD's highlighting what transfer stations do and how they operate. It is clear from the research outlined in this paper that the majority of contractors do not fully appreciate the role that transfer stations play in maximising the potential of construction waste. A method of enhancing the importance of recovery of construction waste materials is required to bring about change in the current system.

In response to the British Government's draft paper *a way with waste*[1] , Waste Watch[5] has highlighted the development of new markets for construction waste as the major issue[5]. In order to achieve this, education and training throughout the entire construction work force (including designers and consultants) is the key to making on-site waste minimisation and recycling programmes fully effective. Unfortunately, without some financial advantage to the practitioners, such programmes may prove difficult to implement. This research project has taken place against a backdrop of increased construction activity within the region and increasing workloads put pressures on organisations and the reality, in many cases, has been that short-term profit has priority over environmental issues such as training, education and awareness.

4. CONCLUSIONS

Potentially a massive market for the re-use and recycling of construction waste exists in Greater Nottingham and the United Kingdom. The recycling infrastructure is established and can be expanded. However, several barriers including the following hinder development:

- The prevailing 'mind-set' of individuals at all stages of the construction process
- A lack of training of construction workers, designers, estimators, buyers etc
- A lack of incentive for companies to recycle
- Limited markets for recycled materials
- A local and national boom in construction
- A lack of segregation of non-inert construction waste
- Negligible local difference between landfill and transfer station tipping rates.

5. REFERENCES

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Weighting health risks in buildings and outdoor environment

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INTRODUCTION

Eco Effect is a system for environmental assessment of buildings, (Glaumann 2000). Health risks outdoors and indoors are assessed, (Hult 2000). These health risks range from cancer, infections, and poisoning to SBS, allergy and various comfort problems. The risk assessments are made on individual scales based on limit values related to what is considered normal and socially accepted according to norms and praxis and what is considered as no risk. The advantage of individual scales is that they refer to established values. Since the assessed health problems are all different the same score representing "acceptable" or "not acceptable" for different problems have different meanings in terms of health risk. To be able to understand and compare the risks the individual scales must be transformed to a common scale, i.e. they must be weighted according to the same concept of risk.

Risk means probability that something bad happens. Risk assessments usually include the negative consequences of the happening. In terms of risk this means that a low probability that something terrible will happen may be equal to a high probability of a less terrible happening. We define health risks accordingly, i.e. as the product of the probability of getting ill and the severity of the illness (or comfort problem). This is the basis for a common scale that facilitates the comparison of mild problems with severe problems, e.g. the risk of being disturbed by noise indoors and the risk of getting lung cancer.

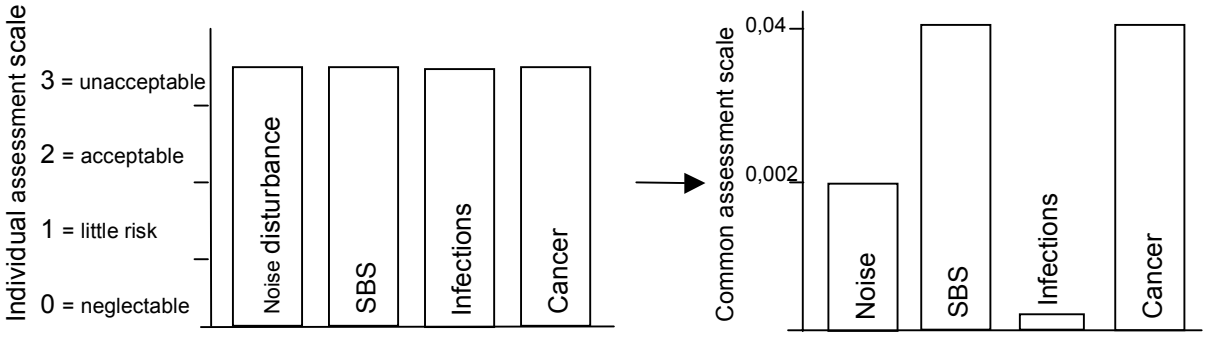

Figure 1. Unacceptable risk for health problems assessed on individual interval scales to the left and transformed to a common quotient scale to the right.

A common scale for risk assessment of different kinds of health problems is proposed in this paper. The weighting processes to adjust the individual assessments to this scale, briefly outlined by a few examples, will continously be developed according to the knowledge and experience gained not least through the use of the method.

A COMMON SCALE FOR RISK ASSESSMENTS

The individual scoring is the starting point for the systematic weighting. All scales in EcoEffect have a score 0 = "no risk" in common. They are interval scales. Score 2 means twice the risk of score 1. Score 2 = "acceptable risk", i.e. the limit between 2 and 3, is the point of comparison. Since the scales are linear it is sufficient to compare just one point on each scale.

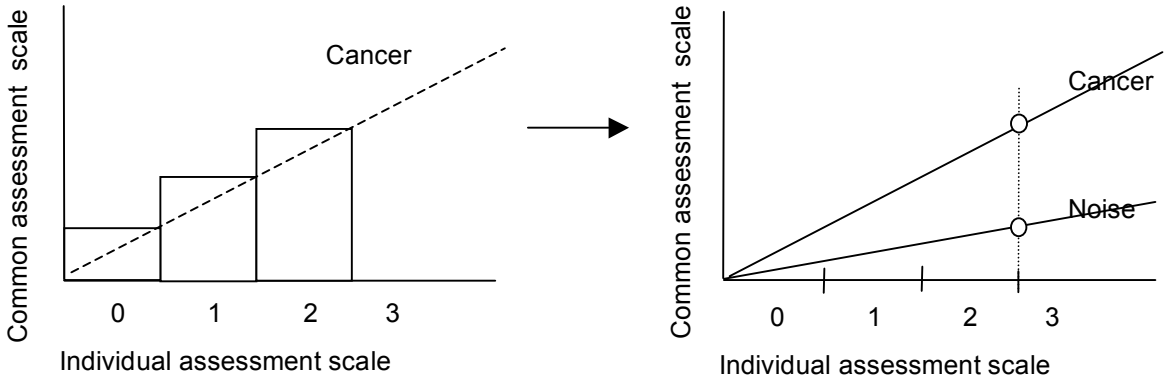

Figure 2. Individual risk scales compared on a common scale: to the left an individual interval scale for lung cancer; to the right it is transformed to a linear quotient scale and compared with disturbance form noise on the same scale. The weight of the individual risk scale is indicated by the inclination of the line.

We use the DALY method for estimating the severity of health problems, (Murray et al, 1996). According to this methodology the damage or suffering due to a disease is quantified as the number of years lived with disability multiplied by a disability weight. The disability weight varies from 0 = "healthy" to 1 = "dead". For mortal diseases the years that may be lost due to premature death are multiplied by the disability weight 1 and added.

DALY = YLD + YLL

DALY (Disability Adjusted Life Years)

YLD (Years Lived with Disability) = duration of disability x disability weight;

YLL (Years of Life Lost) = reduced life years due to the disease

The DALY method has been used to calculate the burden of disease on global and national levels for use in health policy, (Murray et al, 1996). We apply the same methodology on an average individual level to measure the severity of each assessed building related health problem including disturbance from noise, odour, etc. Expressed as a procuct of disability and duration the severity of all health problems can be measured and compared. Multiplied by the probability of occurrence they can all be compared on a common risk scale:

Assessed risk = probability x duration x disability

The probability of being affected by a health problem, the typical duration of the health problem, and the typical disability, (intensity in the disturbance,) are the three weighting factors that will be defined for each assessed and weighted risk.

Cancer develops over a long time whereas infections hit instantly. Comparing the risks of different building related health problems it is important that the probability is calculated for a reasonable long time ahead. A fourth factor, time discounting, may be used to differentiate between instant and future health risks and make up for the fact that people and environment change and that future risks are considered to be much less severe.

The weighting is carried out as comparisons 1) between groups of similar health problems choosing one representative from each group, 2) within groups of similar health problems.

COMPARING RISKS FOR DIFFERENT KINDS OF HEALTH PROBLEMS

Table 1. Health risks in residential buildings compared on a common scale. Disability weights and typical duration for severe upper respiratory infection, allergy, pneumonia and lung cancer are taken from Peterson et al (1998). Other data are estimated.

Type of health problem	Probability	Disability weight	Duration weight	Assessed risk	Time dis-counting	Discoun-ted risk
For comparison: Severe upper respiratory infection	0,35	0,07	0,02	0,005	0,5	0,0025
Outdoor comfort problems	0,2	0,05 -0,01	0,02		0,5	
Example: Noise		0,01		0,0004		0,0002
Indoor comfort problems	0,2	0,05 -0,01	0,2		0,5	
Example: Noise		0,01		0,004		0,002
SBS, aggravated allergy, etc.	0,1	0,05 -0,01	0,66		0,5	
Example: Allergic rhinit		0,012		0,008		0,004
Infections, poisoning	0,01	0,1 - 0,5	0,02		0,5	
Pneumonia (legionella)		0,028		0,0004		0,0002
Cancers Example: lung cancer	0,0012	1	0,2	0,024	0,17	0,004
Theoretical maximum risk: Instantly mortal disease	1	1	1	1	1	1

Table 1 shows a comparison of some health risks representing the range of health problems assessed in EcoEffect. Severe upper respiratory infection is added for comparison. According to a Swedish DALY calculation a person gets an infection 3,5 times yearly of which 10 % are supposed to be severe and lasting a week (Peterson et al, 1998). The intensity of the suffering is estimated to 0.07 on the DALY scale. Allergic rhinit and pneumonia are added to represent

two different groups of similar building related health problems. 100 % risk to die immediately is the theoretical maximum risk = 1.

Probability

In EcoEffect the probability of a building related health problem is defined as the probability that an average user of the building is affected by the health problem.

In an existing building questionnaire responses directly measure the risk for some of the health problems in terms of probability. For residential buildings there is a data bank of questionnaire survey results to refer to, and frequences are age- and gender-weighted, (Engvall et al 2000). More than 20 % of the users disturbed or affected is generally assessed as "unacceptable" for most comfort problems. For other selfreported problems like SBS and aggravated allergy it varies and is lower. The questionnaire method requires a minimum of 12 responders and a response rate of 75 % to give reliable results.

A few health risks in existing buildings are assessed by measurements. The scoring is based on limits for pollution in air and drinking water. These limits are more or less explicitly linked to probabilities to fall ill. "Unacceptable" when it comes to radon emission, for instance, corresponds to a probability of 0,12 % of getting lung cancer after long term exposure to more than 200 Bq/m^3 (Mjönes et al 2001).

Assessments based on design features are linked to the probability that they influence emissions, concentrations, etc that have a detrimental impact on the users' health and comfort. This is the only available method to assess planned buildings. The risk of being disturbed by traffic noise, for instance, is assessed from information on sound insulation, distance to roads and number of cars estimated from traffic models.

The assessments vary in validity and reliability, e.g. assessments based on questionnaires are more valid than measurements, but measurements are more reliable. Validity and reliability influence the probability and must be accounted for though it is not discussed here.

Severity

The DALY calculations are based on health statistics on the incidence and prevalence of different diseases and the average number of years lost due to the disease. Panels of medically trained persons have determined the disability weights in procedures similar to that of health budget discussions. Only a few of the building related health problems assessed in EcoEffect are included in the weighting procedures carried through so far. Disability weights and durations in table 1 have been estimated by comparisons with similar DALY- weighted diseases. The disability weight of "unacceptable" noise, for instance, is assumed to be less than that for a severe upper respiratory infection and in the same range as SBS and allergies.

Comfort problems and some of the building related illnesses ceases after exposure to the environmental load, e.g. disturbance from noise or windiness outdoors, thermal or visual problems indoors. As an average for all the users of a residential building 2/3 of the time is supposed to be spent at home, of which 90 % indoors and 10 % outdoors. (There are no statistics to verify these assumptions. 90 – 95 % indoors, however, is a frequently used figure to underline the importance of the indoor climate.) The environmental load may also vary in time. Noise for instance can be continuous or intermittent, and the duration of "unacceptable"

disturbance may be short and intensive or long and less intensive. Here we assume ”unacceptable” disturbance from an almost continuous traffic noise at a frequency corresponding to 1/3 of the time at home, i.e. 0,9 * 1/3 * 2/3 = 0,2 of all time.

The long duration of comfort problems and some building related and aggravated illnesses makes up for their low disability weights. For mortal diseases like lung cancer the years of life lost dominate the severity, and the years lived with disability can be neglected in the severity comparison. Some infections and poisoning have high disability weights but they are assumed to be of short duration and they are rare and therefore cannot compete in either severity or probability with the other health problems.

Time discounting

Health risks with immediate effects are generally considered to be more threatening than future health risks. Smoking is a striking example of this. In table 1 the probability and the alternative logarithmic time discounting refer to 50 years, i.e. risks are given continuously less weight until they are neglected after 50 years. The discounted risks are calculated as a yearly average over 50 years. Lung cancer, for example, is assumed to be diagnosed after 25 years of exposure to radon, which corresponds to a discount rate of 0,17. Other health risks, like disturbance from noise, do not change with time and the discount rate is assumed to be 0,5 as an average over the calculation period.

WEIGHTING COMFORT RISKS WITH RESPECT TO SEVERITY

The following example concerns indoor comfort problems in residential buildings. The same strategy, however, could be applied to outdoor problems and office buildings. The same probability factor is used in the individual scales for all comfort problems, but the severity may differ and therefore need weighting. The comparison is made with respect to how disturbing the ”unacceptble” levels of the problems are for typical home activities. This means that the disability weight for each comfort problem varies with activity. The severity can be estimated as the summarised products of disability weight and duration for each combination of comfort problem and activity:

$$\text{severity} = \Sigma\,(\text{duration weight for each activity} * \text{disability weight for each activity})$$

There are no data on the average duration of typical home activities, and the comparison will have to be based on estimated duration. (Duration is chosen as a quantifiable and objective measure of importance, but subjectively estimated they would be about the same.) Sleeping and relaxing are assumed to take up most of the time, housework the least. When sleeping noise is supposed to be more disturbing than thermal “discomfort” and light is not needed at all. Light, however, is important for houseworking whereas noise would be less of a problem than for most other activities.

Table 2 shows a systematic weighting procedure for residential buildings. It starts by listing important home activities whith varying demands on comfort. The comparisons start vertically: How long time is spent on sleeping compared to other home activities, etc.? They continue horisontally for each activity: How disturbing is bad air quality compared to noise, etc.? A simple weighting technique is used that starts with ranking to facilitate a distribution of 100 points according to relative weight. Only the points are shown i table 2. After this a horisontal matrix multiplication is made, i.e. the number of points for the duration of each

activity is multiplied by the number of points for the intensity of disturbance. The products for each of these multiplications are added vertically for each comfort problem. Only the result of the matrix multiplication in terms of relative weights is shown in table 2.

Table 2. Comparison with reference to duration (vertically) and disability/intensity (horisontally) of different comfort problems in a residential building.

Activity		Unacceptable comfort conditions concerning…… Air quality	Thermal comfort	Noise	Sun- and daylighting	Artificial light kitchen, bath
Vertical distribution of 100 points with reference to duration ↓		Horisontal distribution of 100 points with reference to how disturbing different comfort problems are →				
Sleeping	25	25	15	60	0	0
Relaxing, TV	20	20	20	40	20	0
Eating, cooking	15	25	20	20	20	15
Studies, reading	15	20	20	40	20	0
Social activities	10	25	25	30	20	0
Personal hygiene	10	30	30	10	10	20
Houseworking	5	15	10	5	30	20
Summary		2325	1975	3625	1450	525
Relative weight	1	0,2	0,2	0,4	0,15	0,05
Discounted risk	0,005	0,001	0,001	0,002	0,00075	0,00025

According to table 2 unacceptable noise is twice as severe a problem as unacceptable air quality, thermal comfort or sun-and daylighting and artificial lighting together. The time discounted risk for noise is 0,002, according table 1. Time discounted risks for other comfort problems are estimated in relation to this in table 2.

CONCLUDING REMARKS

A weighting strategy has been briefly outlined and exemplified by data, which to some extent are tentative. We are just in the beginning. As the weighting work proceeds data will be improved and the arguments more elaborated. When data and arguments are clearly presented in the assessment system they will contribute to a more consistent and concordant view on environmental risks.

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Life-cycle assessment of PVC-U joinery profiles

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1.0 INTRODUCTION

The specification and use of polyvinyl chloride (PVC) continues to be an emotive subject. The desire to quantify the impacts associated with the polymer's formation and enduse has gained increased emphasis following publication of the European Commission's horizontal study into the enduse and disposal of the polymer. The released documentation, which include factors affecting mechanical recycling [Plinke 2000] and the behaviour of the polymer in landfill Sites [Argus 2000], have further added to the polemic views of industry and environmentalists. The UK Government's response to the European Comission's Green considered the Best Practical Environmental Option (BPEO) remains unclear for PVC disposal and the industry requires help in order to meet the challenge of sustainable development [DEFRA 2001].

Every function nevertheless has an appropriate end-use that reflects the service life, geographical scope and the reuse and recycling technologies available. Each material application is therefore unique and therefore no common solution truly exists, only guidance. Basic propositions of material re-use over energy expenditure may be considered, with the drivers being either economic gain or a reduction in ecological burden. The issue of the material re-use is therefore controlled by technical, economic and environmental considerations, the combination of which form barriers to change.

Research conducted by the University of Brighton investigated the interactions between polymer reuse and energy burden. The study focused on the application of unplasticised PVC (PVC-U) using a life-cycle assessment (LCA) methodology based on accepted ISO 14041 [1997] practices. The completed study concerned the identification of the systems relating to a distinct life-cycle and examined the impacts against a specific functional unit (FU) in the form of a single casement window, dimension size being 1000x 1000mm with a polymer content in the region of 14kg. The resultant eco-profile is therefore process specific, quantifying all sub-systems associated with the formation and enduse of PVC-U window framing.

Primary data collection focused on profile extrusion, assembly operations, and the re-use of virgin waste. The principal impacts associated with installation and use of the material as a joinery system were also identified. Mass balancing and thermodynamic techniques underpinned sensitivity analysis of the secondary data utilised for polymer formation sub-systems.

Quantification and qualification of the burdens associated with the eco-profile nevertheless remain complex. The interaction between energy and material re-use, with its resultant effects on the environment, compound assessment. The opportunity to examine and review differing enduse scenarios adds to the complexity of data analysis.

2.0 SYSTEM MODEL

The complex interactions experienced during the eco-profile's life-cycle were analysed via the design and implementation of a computer program. The use of a schematic System Model, as illustrated in Figure One, provides a diagrammatic representation of the process investigated in addition to defining the interrelationship between sub-systems. The computer program addresses four criteria that examine energy efficiency in the form of calorific value and conversion of fuel feedstocks; the process energy used by each sub-system; transportation impact attributed to the delivery of polymer and material efficiency - the amount of waste produced.

The System Model identifies the five primary sub-systems associated with the eco-profile's life-cycle and three enduse scenarios. In addition, the impact of material re-use may also be explored via the inclusion of *Re-use of virgin waste* closed-loop recycling sub-system. The System Model displays both process specific and cumulative value of material, energy and transportation requirements. Cumulative airborne emissions, in the form of eight primary pollutants, further illustrate the eco-profile's total burden. The program therefore provides the opportunity to analyse the embodied energy requirement, transportation impact and the energy mix employed within each sub-system and the life-cycle as a whole.

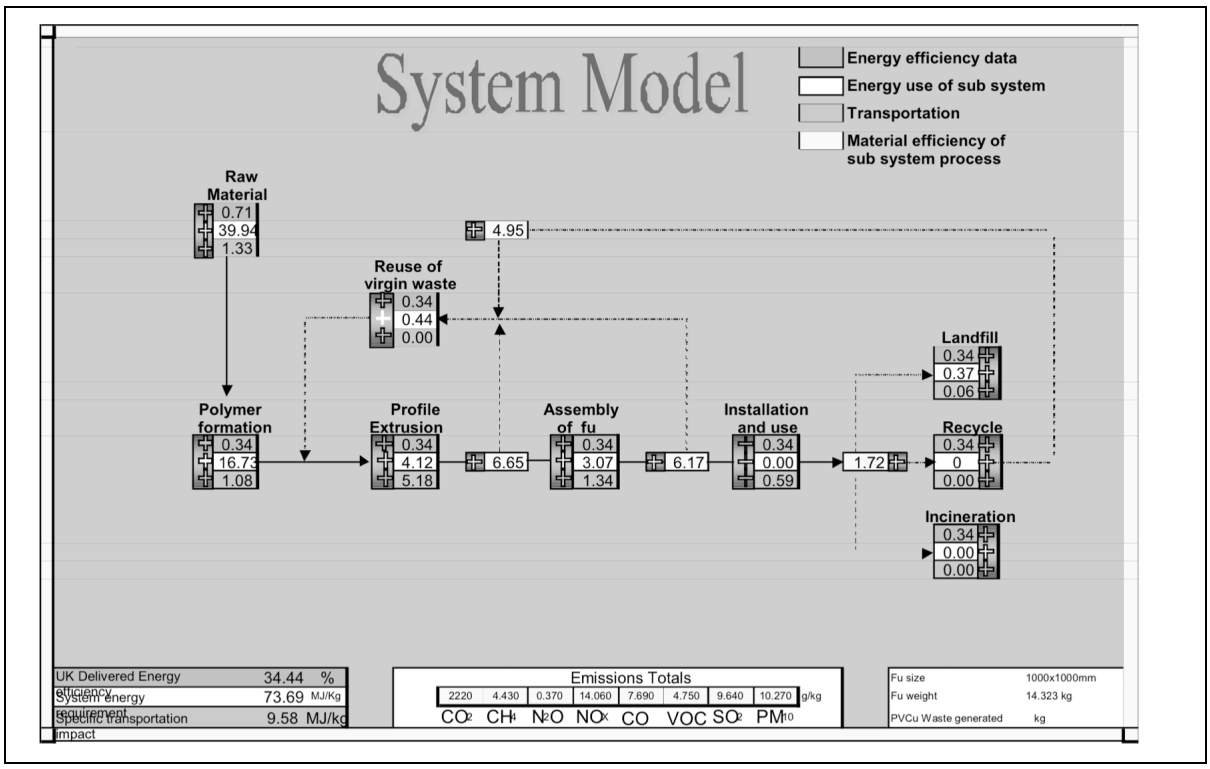
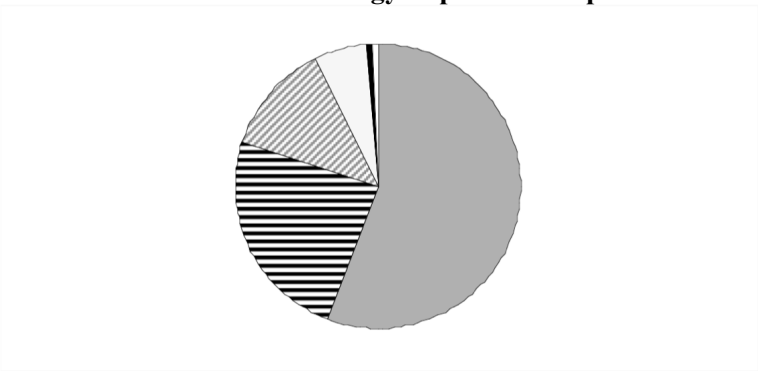


Figure One: System Model Review sheet

The System Model Review Sheet assesses the process specific impacts associated with the formation and output of 1kg mass balanced unit from each sub-system. *Profile extrusion* for example requires 4.12 MJ/kg in process energy. A further 5.18 MJ/kg is expended in the transportation of polymer powder to the extrusion site. Material waste (6.65%) is likewise identified, whilst the conversion efficiency of fuel feedstocks into electricity is assessed to be 34 per cent. The opportunity to model the impacts associated with formation and use of differing geographical regions electricity is thus provided. *Raw Material* formation in Norway therefore records a conversion efficiency of 71 per cent due to the use of hydropower.

The completed inventory analysis of the eco-profile provides a reasoned assessment of the process operations associated with the formation, assembly, use and enduse of PVC-U joinery profiles. The eco-profile cumulative value of 83.27 MJ/kg is comparable with published LCA values which range from 71.55 MJ/kg [IKP 1998] to 138 MJ/kg [Richter 1995]. The energy consumption of each sub-system in isolation and the cumulative impact within the complete life-cycle is identified in Figure Two.

Delivered embodied energy impact of FU profiles



FU: 1000x1000mm full size casement PVC-U window frame
PVC-U material weight: 14.323 kg

Sub-system	Process energy use (MJ/kg)	Transport energy use (MJ/kg)	Total energy use (MJ/kg)	% share
Raw materials	39. 94	1.33	41.27	55.90%
Polymer Formation	16.73	1.08	17.81	24.12%
Profile extrusion	4.12	5.18	9.30	12.59%
Assembly	3.07	1.34	4.41	5.97%
Installation and use	0.00	0.59	0.59	0.79%
Landfill	0.04	0.40	0.44	0.59%
Cumulative impact	**73. 69 MJ/kg**	**9. 58 MJ/kg**	**83. 27 MJ/kg**	
Cumulative CO_2	1425	795 g/kg	2220 g/kg	

Figure Two: Eco-profile delivered embodied energy impact of PVC-U window joinery

2.1 Process energy

The extraction of raw materials extraction together with the formation and transportation of the polymer accommodates 80 per cent of the eco-profile's delivered energy consumption. The energy intensive activities of chlorine formation, the thermal cracking of naphtha and conversion to ethylene dichloride for processing into vinyl chloride monomer subsequently have a significant impact on the life-cycle of the eco-profile. Process allocation and delivered energy efficiency nevertheless alleviate the total environmental burden. Further, the high sub-system value is partly attributed to the cumulative impact of waste from downstream processes, which increase sub-system process energy use by 13 per cent. Transportation impact is likewise increased.

Conversion of the polymer powder into joinery profiles and their assembly into the casement window utilise 13.71 MJ/kg. This represents in the region of 18 percent of total life-cycle energy consumption - nearly half of which is attributed to the carriage of the PVC-U profiles between *Profile extrusion* and *Assembly* operations sub-systems.

2.2 Transportation energy

The transportation distance attained during the eco-profile's life-cycle is in excess of 5400 km and provides a significant contribution to total life-cycle energy use. The carriage of low-mass materials increases total life-cycle transportation use to 11 per cent. As a consequence the delivery of profile lengths to the assembly site displays a four-fold increase in energy consumption over bulk transportation of polymer powder. Empty vehicles on return routes further add to the inefficiency of regional distribution.

3.0 DISCUSSION

The environmental impact of the eco-profile is primarily attributed to polymer formation, the transportation of extruded joinery profiles and the fuel feedstock mix associated with delivered electrical energy. Material waste generated in *Profile extrusion* and *Assembly operations* sub-systems further increase the life-cycle burden due to the cumulative impact on upstream operations. Increased efficiency in polymer formation over recent years [Krähling 1999:Boustead 1998] offers little opportunity to provide significant process energy savings. The machine processes involved in the *Profile extrusion* sub-system also offer limited scope for consistent energy savings due to the variabilities experienced in profile extrusion and associated downline calibration processes.

Enhancing the eco-profile of PVC-U joinery profiles within the UK may however be attained by exploring three considerations; delivered electrical energy efficiency, the re-use of virgin PVC-U waste generated and the transportation of goods between each sub-system.

Electrical energy efficiency is determined by primary fuel mix employed and the method of conversion. Delivered energy efficiency within the UK in 1998 was in the region of 34 per cent [DUKES 1999] due the continued reliance on coal feedstocks. Virgin PVC-U waste generated during the eco-profile's life-cycle has a cumulative impact in the region of 13 per cent. Existing enduse operations for the eco-profile result in the PVC-U waste being recycled into low-grade systems.

Moreover, the carriage of high volume joinery profiles and empty return transport account for two-thirds of total life-cycle transportation energy use. As a consequence improvement analysis of the eco-profile must target the interaction between material reuse, the use of existing logistics to return virgin waste and the increase in delivered electrical energy efficiency. As the Systems Model program may explore the previous considerations, the potential of reducing the cumulative life-cycle impact of 83.27 MJ/kg may be considered by optimising the transportation and re-use of material scrap.

4.0 MODELLING RE-USE OF PVC-U SCRAP

The System Model review sheet illustrated in Figure One identified the polymer waste generated during profile extrusion and assembly operations. Closed-loop recycling of the resultant virgin waste may be attained by the inclusion of a regranulation process. The developed model enables the potential gain of material reuse to be investigated. Table One identifies the primary impacts associated with the differing reuse scenarios. FU provides data on the completed eco-profile for the life-cycle of the four joinery profiles specific to the original study [Flanagan et al 1999].

Table One: Modelled PVC-U re-use scenarios

Scenario	Recyclate percentage	Process energy	Transportation energy	Total energy Use	Cumulative energy	Process CO_2	Transport CO_2	Total CO_2

	input	loss	(MJ/kg)	(MJ/kg)	(MJ/kg)	saving	(g/kg)	(g/kg)	(g/kg)
FU	-	-	73.69	9.58	83.27	-	1425	795	2220
1	5	5	70.37	9.22	79.59	4 %	1385	765	2150
2	5	10	67.26	12.27	79.53	5 %	1213	1039	2252
3	10	25	62.11	11.87	73.98	9 %	1224	1104	2328

4.1 Scenario One: Re-use of extrusion scrap

Scenario One identifies the reintroduction of five per cent "in-house" PVC-U waste generated during the extrusion of the FU profiles. The regranulation of virgin waste incurs its own energy use of 0.22 MJ/kg and experiences a five per cent recyclate loss from the system. The reintroduction of the recyclate provides a 3.32 MJ/kg reduction in cumulative energy consumption due to a decrease in upstream processing requirement and transportation. Carbon dioxide emissions reduce accordingly.

4.2 Scenario Two: Re-use of extrusion and assembly scrap

Scenario Two explores the life-cycle impact of further improving the previous preposition by returning assembly waste to the extrusion site via the existing transportation system in place. The System Model can subsequently examine the impact of processing a second "batch" assembly waste in addition to Scenario One extrusion waste use. Material reuse quantities are determined to be five per cent for both extrusion and assembly, against a respective five and ten per cent reuse sub-system process loss. Cumulative process energy reduces to 67.26 MJ/kg - a eight per cent process energy saving over the eco-profile. This saving is however offset by an increase in transportation energy due to the return of assembly waste to site.

4.3 Scenario Three: Re-use of extrusion, assembly and enduse scrap

Re-use scenario Two investigated the reintroduction of a maximum ten per cent recyclate as permitted in BS 7413 [1992]. Scenario Three examines the life-cycle impact of reprocessing enduse PVC-U joinery and employing a further ten per cent scrap. The total recyclate content is therefore in the region of 17 per cent, given a sub-system reprocessing loss of 25 per cent. The energy use associated with segregating the polymer from redundant joinery adopts a reprocessing energy use of 1.08 MJ/kg. This value reflects the process energy consumption of the VEKA automated reprocessing plant [IKP 1998]. The collection and delivery of the enduse recyclate also incurs a modelled transportation impact associated with the carriage of a three tonne load over 400km using rigid 14-17t diesel vehicle. A factor of 1.7 quantifies empty return.

The increase in material recyclate enables Scenario Three to record the greatest reduction in scenarios modelled. The nine per cent reduction in cumulative energy use over the eco-profile is primarily due to a significant reduction in virgin material required. *Raw Materials* and *Polymer Formation* sub-systems record a revised sub-system process energy use of 35.28 and 14.77 MJ/kg respectively (eco-profile values being 45.99 MJ/kg and 19.26 MJ/kg). Increased transport distance is offset by the reduction in the carriage of virgin polymer.

The carriage of low-weight recyclate however results in transportation emissions increasing by 15 per cent, whilst the additional electrical energy required by the *Re-use of virgin waste* sub-system further negates the savings associated with material reuse. Indeed as *Raw Materials* formation predominately utilises hydro energy, the opportunity to reduce emissions is restricted. Airborne emissions consequently increase, with total carbon dioxide value rising by three per cent

5.0 CONCLUSION

The FU embodied energy impact of 83.27 MJ/kg is primarily associated with the formation of the polymer compound and transportation impact during the life-cycle investigated. Material waste generated during profile extrusion and assembly increase the cumulative impact of polymer formation by a further 13 per cent. The System Model developed enables the complex interactions experienced between material re-use, transportation energy and resultant impact on upstream processes to be assessed. In turn program operation allows differing enduse scenarios to be investigated and therefore quantify the impact of material re-use and recycling. The reintroduction of ten per cent recyclate for example attains a net reduction of five per cent over the specific eco-profile. The reapplication of scrap material into new profile systems subsequently reduces the burdens associated with upstream polymer formation.

The re-use of both virgin and PVC-U waste can therefore provide a significant benefit on reducing the life-cycle impact of the polymer. Prognos [2000] concurs this consideration and accepts virgin scrap and post consumer wastes provide an environmental advantage where the polymer can be readily separated. Moreover, Weinlein's LCA into PVC-U joinery [1996] enforces this assertion by identifying the reintroduction of 70 per cent recyclate provides a recycled profile with life-cycle energy savings in the region of 50 per cent. As consequence environmental assessments conducted by Krähling [1999] conclude the ecological burden of the polymer becomes comparable with all other joinery systems when material recycling is adopted.

As true re-use and recycling remains concerned with saving energy and materials over the total life-cycle, the reapplication of PVC-U scrap in new systems therefore negates the burdens associated with polymer formation - the eco-profile's greatest sub-system impact. The values generated by the System Model enforce this consideration, with the reintroduction of ten per cent recyclate providing comparable life-cycle savings.

The environmental impact of PVC-U joinery can be subsequently reduced within existing performance controls by the co-ordination of sub-system processes associated with the material's life-cycle. However under current specification standards governing white PVC-U joinery profiles, a higher eco-profile saving of the eco-profile investigated cannot be reasonably provided due to the performance requirements of this study's joinery system precluding a higher recyclate content. A caveat to this consideration remains that substantial quantities of reworked polymer could be included without loss of performance should the FU follow a different mode of profile reuse, including for example coextrusion and foil coated systems.

The previous scenarios highlight the balance between material processing and energy use, with a rise in polymer reuse being offset against an increase in process and transportation energy. Energy use is subsequently proportional to recycling and forms a defined curve of environmental burden based on parameters that remain unique to each life-cycle.

The mechanical re-use and recycling of the material into high value products therefore reduces the ecological burden of its formation. Co-ordination of the infrastructure required for collection segregation and reprocessing negates life-cycle transportation burdens. The key of the polymer's continued specification and use as a joinery system consequently remains not with its formation and use - but that of its enduse.

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Environmental service product package for real estate sector

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1 INTRODUCTION

1.1 Background

Jaakko Pöyry Infra Consulting is a high-level consulting group specialised in business and process development. The group employs total 50 professionals from real estate, telecommunications, construction, service and industry sector. The group is a part of Jaakko Pöyry Corporation, a global consulting company, in the fields of forest industry, energy, infrastructure and environment, with offices located more than 30 countries worldwide.

Year 1999 environment was chosen as one of the strategic core areas of the corporation and thus also Jaakko Pöyry Infra started systematically developing its environmental services, including environmental consulting for real estate sector. The development was further accelerated in the footsteps of development program called ProgGresS, the initiative for environmentally sound building and facility management practices development in Finland.

The environmental consulting team of JP Infra Consulting specializes in environmentally sound construction and design practices, environmental strategy development, and process and management tools development. Its clients range from international, large user-owners and institutional owners to real estate management organizations and constructors.

1.2 Purpose and contents of the paper

The purpose of this paper is to present how JP Infra Consulting has succeeded to create demand for environmental consulting services in real estate sector and developed previously, mostly scientifically used methods into profitable service products. First, client requirements and challenges for marketing are presented. Then, the chosen approach to answer these requirements of JP Infra Consulting are illustrated. Finally, some most successful product concepts are described in more detail.

2 MARKETING CHALLENGES

2.1 Client requirements and requirements for marketing

Environmental awareness of real estate business in Finland has emerged only roughly five years ago. Following the changes in the business environment, some re-evaluation of products and processes from the environmental viewpoint are on the agenda of most of the

organisations in the field. However, there is still a remarkable gap between acknowledgement and present know-how. Clients want to ”do something” for their environmental performance, but are unaware of the concepts and possible practical approaches for sustainable building.

Successful consulting services marketing requires active communication with potential customers and recommending them solutions, thus differing from the marketing of more traditional and established design (e.g. architecture and HVAC) services in the sector. Prospective clients only occasionally initiate the contact with service providers or use competitive bidding. This is because the clients often have difficulties defining the required service and don’t have enough information about the best solutions and approaches when first developing their environmental work.

2.2 Chosen solutions and approaches

JP Infra Consulting has faced the challenge to educate its clients, seeing the benefits of environmentally sound management practices and construction. The unit has developed its environmental services into product concepts where the outcome, such as reports and analyses, and the approach, such as the service process and used methods, is defined.

By developing the service products into a well-defined product package JP Infra Consulting eases the client’s buying process and further the project start-phase. Service products are used as a framework when offering customers tailored solutions for their problems. The client is able to see possible solutions for his/hers problem and to make alterations, tailored for their specified needs. The product set consists of six products packages:

- Environmental management of a construction project
- Environmental strategy development
- Environmental review /audits of operations, processes and management tools
- Environmental training
- EMS development
- Life cycle analyses and their applications

3 PRODUCT CASES

3.1 Environmental Review

Environmental strategy and management development among estate owners and managers in Finland has been slowly increased along the international development trends. However there appears to be ambiguous conception about whether there is true competitive advantage to invest on environmental management beyond the actions now done routinely, such as investments on energy saving.

JP Infra Consulting Environmental Review has been popular among real estate owners and management companies, to produce a base for environmental strategy development. The Environmental Review consists of quantitative analysis of organisation’s environmental impacts, identification and assessment of organisation’s environmental risks, extensive stakeholder analysis and a management practices audit (Figure 1).

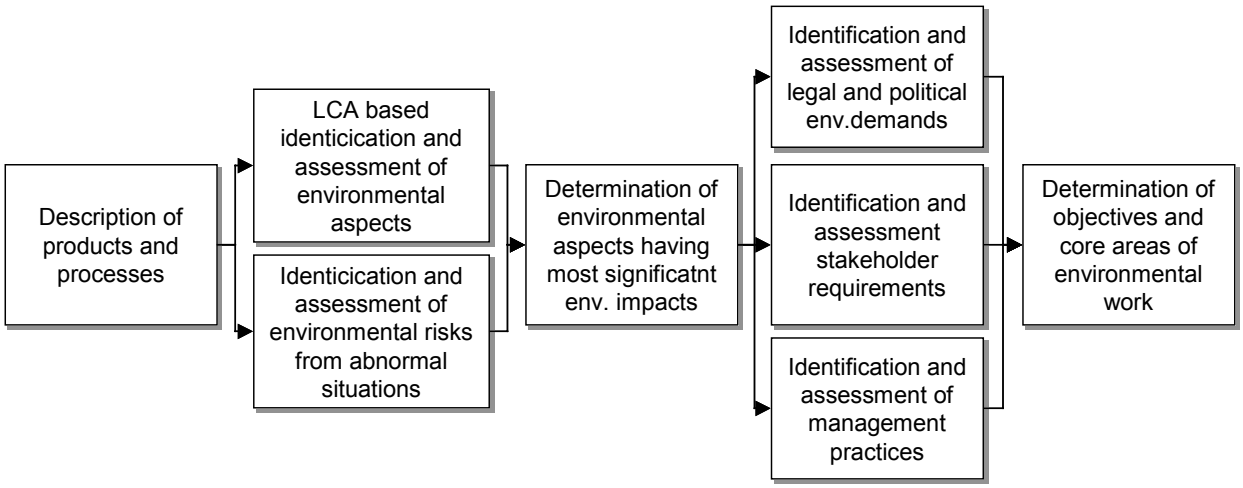

Figure 1 The process of Environmental Review

Purpose of the review is to collect and analyse information about the external and internal business environment of the client organisation and to determine its significant environmental aspects in order to define organisation's critical success factors related to environmental management. Impartial assessment of organisation's current position in the field and knowledge about the magnitude and severity of its environmental impacts helps the organisation managers to make grounded decisions when formulating business strategies and communication.

3.2 Technical Specifications Matrix

One approach to manage construction projects in environmentally conscious way is to transform the set environmental targets into technical specifications for designers and constructors. This, combined with cost management and tight project schedules is usually a very challenging task requiring high-level know-how and experience of environmentally sound practices.

In order to help the specifications settings JP Infra Consulting developed, together with its clients a Technical Specifications Matrix. It translates environmental targets and politics of a constructor into technical specifications; "technical language" understood by designers. Table 1 illustrates the structure of the Matrix and some specifications set for heat energy for a new hotel project.

Heat energy

Subject	Unit	Project value	Base/norm	Good	Premium	Additional specifications	Responsible
Annual consumption of heat energy	kWh/net-m^2K		158 kWh/m2		40% below the base level	*Benchmark: Average consumption levels of current building portfolio*	HVAC engineer
Heat transmission coefficient for windows U	W/m^2K		2,0		1,0	*90% of the total surface area of windows are 2- or 3 - glassed windows*	Structural engineer
Heat transmission coefficient for exterior walls U	W/m^2K		0,28		0,20		Structural engineer
Heat transmission coefficient for roofs U	W/m^2K		0,22		0,16		Structural engineer
Heat consumption metering	Q		One main gauge	additionally ventilation, room heating and service water			HVAC engineer

Table 1 An example of Technical Specifications Matrix developed for a hotel.

The environmental issues are taken into consideration widely; the site, indoor environment, consumption issues, risks and convert flexibility of facilities. Environmental targets are set individually with the customer according to their definitions of environmental policy and technical specifications are set in co-operation for each functional element of a building. Three alternative specifications are defined: for the minimum norm level, "good practice" and premium level, presenting BAT. The specifications can be either numerical or qualitative. As a result, the client will receive a matrix, with which the specifications of an individual project can be chosen.

The Matrix has been found out to help concretising the targets also to persons unfamiliar with the detailed technical design and thus to help the co-operation with designers and facilitate the bidding process. It serves as a checklist for aspects to be concerned in a project and serves partly as source information for special designers. It also aims at finding critical factors for each sector, thus helping concentration of actions.

For further use; communications and marketing, the matrix illustrates the chosen level against minimum norm, good, and premium –levels working as a base for example for eco-labelling/classifications and environmental declarations. When completed with practical experiences and company practices, the Matrix may also act as a base for design guidelines.

3.3 Environmental Profile of a Building

Environmental profile of a building is one application of life cycle assessment tool for buildings. It differs from traditionally used approach, where separate design solutions and system parts are compared with LCA to find the environmentally soundest alternative.

Here, the environmental burdens caused by a building during its life cycle are assessed and presented by their occurrence; building materials, site, use, renovation and terminal value. Figure 2 illustrates this approach.

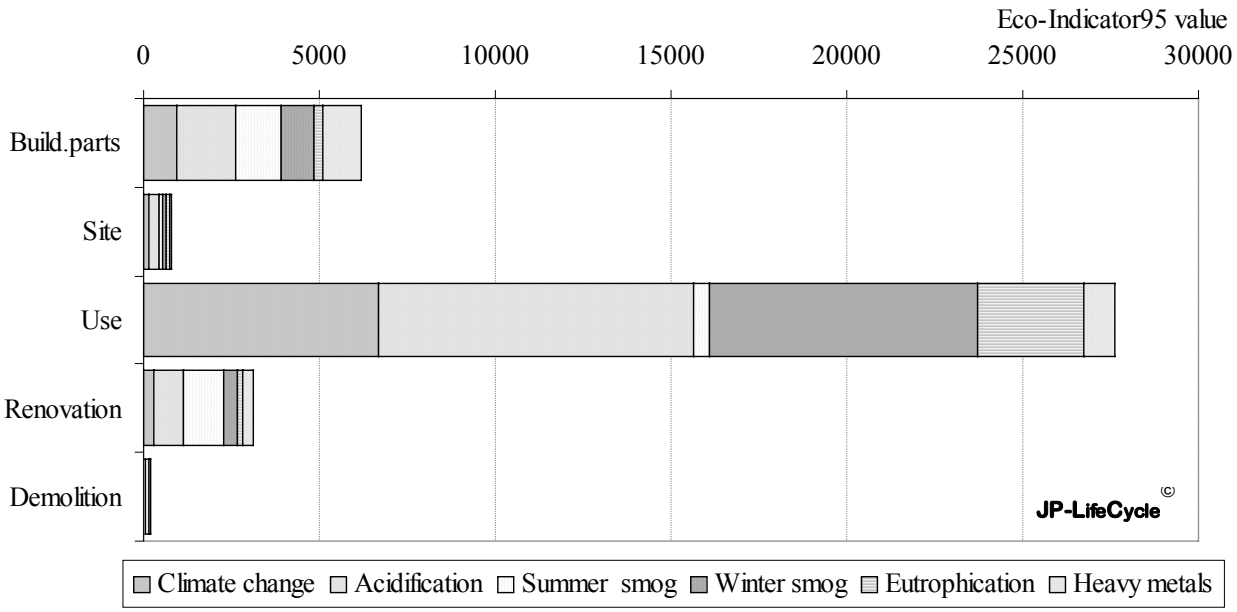

Figure 2 Type and distribution of a building's environmental burden during a life cycle of 50 years.

The approach is used to visualize the environmental impacts and to recognize the significant environmental aspects of a project during its whole life cycle. It also enables comparisons between aspects in client's interest, for example: cost versus impact distribution, construction costs versus impacts of construction, and comparisons between design or material alternatives. Summaries can be presented in relation to previous projects, average projects, and e.g. annual emissions of Finland or Europe. By assessing the environmental impacts of a whole building, instead of merely comparing functional elements, resources and actions are more effectively concentrated and the effect on total life cycle costs are better understood.

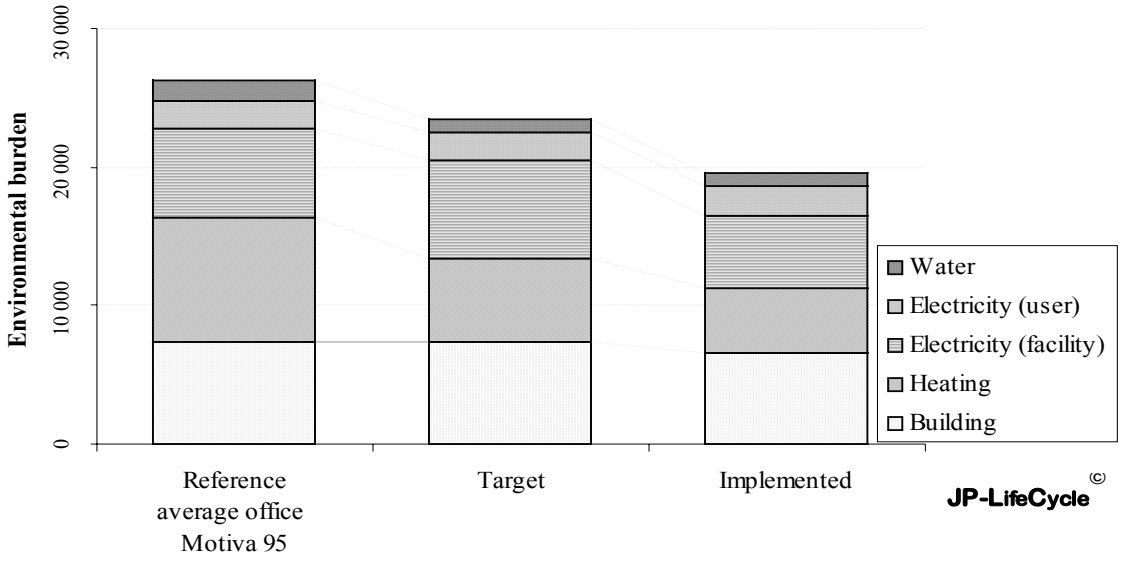

Figure 3 Results of LCA –controlled design for a new office building.

Figure 3 illustrates results of a new office building project, where LCA was used to calculate the environmental burden and life cycle costs of the building, based on preliminary plans, and then used for design solutions and systems selection.

4 CONCLUSIONS

In professional services, full process standardisation and exact product concepts are seldom required –especially with environmental services, where even customer needs, not to mention best practices, are still developing rapidly. The possible degree of standardisation depends also on the type of service. For example, the audit-type character of the Environmental Review has enabled its relatively high standardization compared to other service products of JP Infra Consulting. However, even a loose product framework facilitates remarkably services marketing and project management.

Standardized questionnaires, approach methods and printouts save both the client's and consult's time, ease the marketing of the product and lower the buying threshold of the service. Product descriptions have been experienced to accelerate the project-opening phase and also helped evaluating the given results. Also, product development in co-operation with clients has been experienced to accelerate, when there is an initial framework for the purpose, scope and process of the service product. The contents of the product package of JP Infra Consulting support each other, and the variety of approaches, depth of analyses and requirements set for the client allows customers to choose a product suitable for their individual need.

Customer feedback has supported the initial assumption about the benefits of the product concept development. Customers do not want to execute environmental analyses and development programs just out of curiosity without knowing where to use the service. Advantages and benefits for the customer are the most important issues to be considered when developing a service product package.

CRISP Network on Construction and City related Sustainability Indicators: Structuring of Indicators and status of work

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1. INTRODUCTION

1.1 European thematic network CRISP

The paper summarises the midterm results of the European thematic network CRISP (2001) from the point of view of methodological aspects and describes the current status of the project. The CRISP network within the 5th Framework of the EC started in June 2000. The main activities of the CRISP Network, gathering 24 members from 16 countries are to

1) define a framework and general methodology for indicators,
2) stimulate and co-ordinate the development and use of indicators,
3) gather indicators within a database and
4) widely disseminate the results of the research carried out.

1.2 Sustainability indicators - state-of-the-art

The CRISP framework of construction and city related sustainability indicators is based on the viewpoint that sustainable construction brings about the required performance with least unfavourable or the most favourable ecological, economic as well as social and cultural impact both in local and regional as well as in global level.

Sustainable construction is an important part of sustainable development, and it should follow the basic concepts expressed from the general point of view. The development of the conceptual framework for sustainable development has recently taken place in terms of developing and structuring sustainability indicators. From general point of view, valuable results have been published e.g. by OECD and EEA.

The state-of-the-art review worked out by CRISP thematic network characterises indicators to be measures, which enable information on a complex phenomenon to be simplified into a form that is relatively easy to understand. According to OECD terminology an indicator is a parameter, or a value derived from parameters, which points to, provides information about, describes the state of a phenomenon / environment / area, with a significance extending beyond that directly associated with a parameter value; a parameter being a property that is measured or observed. An index is defined as a set of aggregated or weighted parameters or indicators. However, the CRISP network also uses the term indicator for other signs than directly measurable numerical values. According to CRISP, indicators can also be qualitative

signs, which can be graded with help of classification. The sustainability of buildings can be indicated with help of classification and the criteria can be based both on quantitative as well as on qualitative matters.

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Indicators enable us to monitor the change of phenomena over time and the development of phenomena in relation to stated objectives. One of the important functions of an indicator is its potential to show the trend, i.e. the course of development, in an early stage. Indicators should be objective and the results should be repeatable. In many cases indicators should also be internationally comparable, although they will most often be used nationally. The main risk with regard to indicators concerns excessive simplifying and the loss of important information.

Agenda 21, chapter 40 states that "Indicators of sustainable development need to be developed to provide solid bases for decision making at all levels, and to contribute to a self-regulating sustainability of integrated environmental and development systems." In relation to policy-making, environmental indicators are used for three major purposes (EEA 1999):

1) to supply information on environmental problems, in order to enable policy-makers to assess their seriousness;
2) to support policy development and priority setting, by identifying key factors that cause pressure on the environment;
3) to monitor the effects of policy responses.

Generally, indicators are not only needed in order to supply information about the state and condition and causalities, but also to assess the effectiveness of alternative responses. The building sector does not need indicators only to assess and show the environmental quality of buildings or the built environment, but also to support the planning and design of sustainable buildings. When developing and selecting indicators, the starting point is the identification of main users and user needs. Construction and city related sustainability indicators are needed by a number of parties in the building sector. Indicators are needed in decision making by

- public bodies (housing, building, traffic, environment)
- owners of real estate
- facility managers
- occupiers and users of buildings
- contractors
- planners, developers and designers
- manufacturers of building products.

The United Nations' Commission on Sustainable Development (CSD) has worked out a working list of sustainability indicators. This should be seen as a flexible list from which countries can choose indicators according to national priorities, problems and targets. Indicators are presented in a Driving force State - Response framework. 'Driving Force' indicators indicate human activities, processes and patterns that impact on sustainable development. 'State' indicators indicate the 'state of sustainable development and 'Response' indicators indicate policy options and other responses to changes in the 'state' of sustainable development. The OECD and the European Environmental Agency (EEA) have also worked out typologies of indicators. The EEA uses the DIPSR (Driving forces, Pressure, State, Impact, Response) framework in its reporting activities. According to EEA report (l999) indicators can be classified into four groups Descriptive indicators (DRISR-framework) Performance indicators, Efficiency indicators and Total welfare indicators. CRISP has adopted the EEA typology as the starting point, but does not exactly follow the general

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outline of sustainability indicators, because it is worked out in order to be used at a whole-society or community scale rather than in a product or building scale.

Indicators and assessment methods are needed for the purpose of comparison and prioritising. This brings about the importance of defining the basics for comparison. The service that is provided by a building asset can be described with help of its performance. Thus the performance of a building can be used as the basis of comparison - as the functional unit in terms of LCA terminology. On the other hand, some aspects of performance like access, healthy indoor environment, safety and adaptability can be used as sustainability indicators as such.

The CIB report 'Working with the performance approach of building' (1982) describes the performance approach as being concerned with what the building is required to do, and not with describing the technical solutions i.e. how it is constructed. CRISP network recommends the required building performance be used as a basis when alternative building designs or alternative buildings are compared to each other from the sustainability point of view. Unlike the EEA, CRISP uses the term 'performance' according to CIB to characterise the type of indicators that express the behaviour of a product related to use. This includes access, safety, health and comfort related indicators.

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The European network BEQUEST (2000) has outlined the impact of construction on sustainability as follows:

1) Environmental: use of natural raw materials and energy, environmental pollution, land use, bio-diversity, odours, noise;
2) Economic: Economic development and finance, Urban and community services, Production and consumption;
3) Social: Access, Safety and security, Health and well-being, Community responses and human capacity, cultural heritage.

This was taken as the starting point by CRISP, when structuring the indicators according to the sustainable development issue.

2. STRUCTURING OF INDICATORS

The CRISP network has structured the sustainability indicators according to Type, Impact level; Sustainable development issue; and Construction category.

3.1 Type of indicators

CRISP structures the type of indicators according to the following items.

1 Pressure; Pressure indicators describe developments in the release of emissions, the use of resources and land.
2 Performance; Performance indicators describe the behaviour of product in its intended use.
3 State; State indicators describe the quantitatively and qualitatively physical phenomena (like temperature or level of noise in certain area), biological phenomena (like wildlife resources present), chemical phenomena (such as concentrations of harmful substances) and social, economical or cultural phenomena (like average living area).
4 Impact; Impact indicators describe impacts caused by the changed state of the environment and built environment, for example impacts with regard to bio-diversity, available resources and provision of adequate conditions for health or security.
5 Response; Response indicators describe responses by groups in society and enterprises as well as governmental attempts to prevent, compensate or adapt to changes.

6 Efficiency; Efficiency indicators relate pressures to human activities, responses or performance of products. These indicators provide insight in the efficiency of products and processes in terms of used resources, released emissions and generated waste per unit of product.

The outlining tries to follow the EEA typology, however taking into account the specific building-related issues. The most important difference concerns the definition of performance. CRSIP follows the CIB definition instead of that of EEA. In addition, the outlining does not include driving force indicators, because those are the-whole-society related rather than building related indicators.

3.2 Impact level

CRISP outlines the impact level in four categories as follows:

1 Global: world-wide, international
2 National : at the country scale
3 Regional : a region is defined as a sub-part of a country
4 Local : at the town or neighbourhood scale

3.3 Sustainable Development issue

Sustainability indicators are also characterised according to the sustainable development issue. CRISP follows the three-section outlining as follows:

1 Environmental: *Natural raw materials* including the use of water. *Bio-diversity*. *Energy*. *Environmental pollution. Land use*
2 Economic: *Economic development and finance*, indicators dealing with costs, productivity, profitability etc. *Production and consumption*; indicators, which describe the quantity or quality of production or consumption. *Urban and community services and responses*; indicators that deal with economic responses etc.
3 Social: *Access*; access to buildings and built environment, barrier-free use, access to information, affordability (with regard to housing etc). *Safety & Security*; including crime, fear of crime, home safety, road safety, fire safety, industrial hazard, natural hazard, natural catastrophe. *Health and comfort*; including sense of well being and comfort (thermal, visual, acoustic comfort); Socio-economic well-being (with regard to housing etc). *Community responses*; including social support, social exclusion, vitality of community/city/centre, stewardship, education for and understanding of sustainable development with regard to buildings and built environment, adaptive management ability, environmental management, spatial segregation, equity of minorities with regard to housing etc. *Cultural heritage*

3.4 Construction category

CRISP divides the sustainability indicators according to construction category into five groups, which are Urban, Infrastructure, Buildings, Building products and Processes.

3.5 Use of indicators

CRISP network collects sustainability indicators both as individual indicators and as systems of indicators. In practice, sustainability indicators of buildings and built environment are normally made use of as indicator systems or as sets of individual indicators rather than as individual indicators. CRISP characterises the use and status of indicator systems according to the following items:

1 Developer
2 Purpose; like diagnosis, monitoring, assessment, design

3 Implementation scale, like unit scale, multi-unit scale, country scale, European scale
4 Users; Owners, Users and inhabitants, Public bodies and planners, Designers, Developers, Contractors, Producers, Facility managers,
5 User countries.

This information is believed to describe the status and implementation of indicators and sets of indicators.

4. CRISP - description of the data basis

4.1. Structure of the database

The main result of CRISP network will be the collection of sustainability indicators and their related systems into a database, made available for the end-users on the Internet. The database structure is based on two linked data sheets : the "indicator data sheet", documenting the indicators individually, and the "system data sheet", documenting the sets or systems of indicators. An indicator may belong to one or more systems, and a system is made of several indicators. The figure 1 presents schematically how the two complementary types of data sheets are linked inside the database, so as the user be able to navigate from indicators to systems and from systems to indicators. As the information contained in each data sheet is necessarily limited, the data sheet can include in the field "references" an Internet address, allowing the user to access directly to more detailed information.

4.2. Expected functions and end-users' viewpoints

The potential end-users of the CRISP database are very diversified. Their concerns and interest are therefore also diverse Consequently, the search function of the database must be as flexible as possible in order to reflect these various viewpoints. That means that the user should be able to enter the database through different sets of criteria.

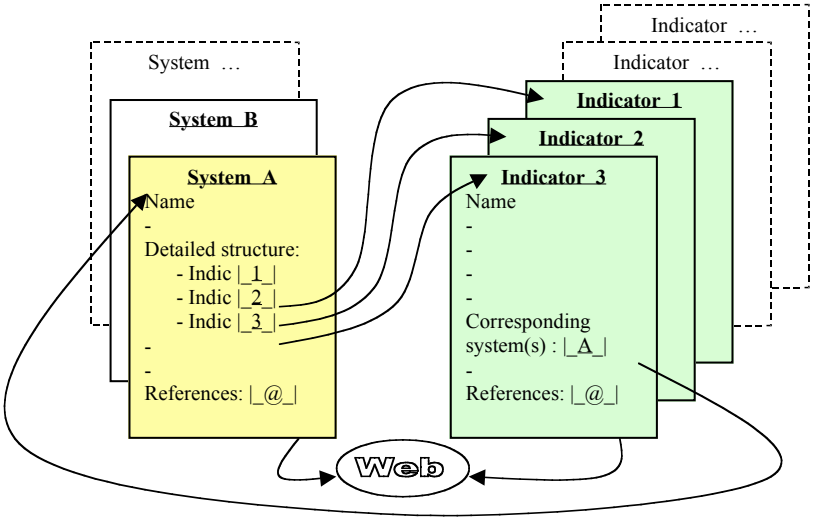

Figure 1. How the 2 CRISP data sheets are linked inside the database

For an end-user, the objectives of the utilisation part are :

- to get an overview of the whole contents of the database
- to search indicators or systems according to a "certain number" of criteria, selected among the whole set of criteria and sub-criteria (ticked boxes of the data sheets) in a flexible way, adapted to the needs and concerns of each end-user
- to complete the search with one or several keywords (search in text fields of the data sheets)
- to get a list of the selected data sheets
- to visualise the full contents of the selected datasheets
- to be able to navigate between indicators and systems datasheets, using the internal links of the database
- to get more information on an indicator or a system, through possible web external links
- to print or download valuable information
- to modify the current request or to create a new one

4.3. Example of end-users' feedback

The CRISP members arranged end-user meetings, and during the latest ones, the end-users commented on the structure of the datasheets in terms of usefulness and readability. For example, the end-user meeting arranged in Finland in February 2002 gave the following feedback:

- CRISP indicator System Sheets seem promising in practice, especially if they have active links to related Web-sites with references
- it's important to know if the Indicators or Indicator Systems have an official status somewhere or if they are widely/frequently used
- individual indicators may have a very limited applicability as such, but in a form of systems of indicators they add value to the current practice
- indicator reference values and various search functions would be practical.

At the beginning of 2002, 259 indicators, gathered in 17 sets or systems, have been collected through CRISP members. A prototype has been set up in order to demonstrate to the end-users the contents and the structure of the database.

5. CONCLUDING REMARKS

The CRISP Network has defined a framework for indicators and collected and outlined indicators in accordance with the framework. The collecting of indicators and the building up of a data basis is still going on. The idea is to collect a reasonable number of well organised indicators and thus support the use and development of appropriate sustainability indicators in the different stages of building process.

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GB Tool: Scope for user-interface project assistance (Diversifying the end-use)

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1. INTRODUCTION

"Australia is responding too slowly to the challenges of global and national sustainability", this observation of Graham Harris (Harris, 2002) can be observed in building industry's slow actions against the fast approaching environmental crisis.
In a time when environmentally well-informed building professionals, stakeholders and users are responding but acting slowly, there is a need for some serious initiatives. A range of tools/methods and schemes claim to support building industry's pursuit for sustainability, however the diffusion of these tools remains the critical issue.

This paper concentrates on the potential in building assessment methods for that sought- after dispersal of green actions. Covering a range of environmental considerations and a holistic evaluation of buildings, assessment methods also facilitate promotion of other support tools and green initiatives. The need is to have a diffusion plan that brings these methods right in the center of organizational initiatives of green building design, construction and operation management and decision making, equipping building professionals with a greater ability to undertake environmentally benign actions. What is needed is to have a green project-assistant tool that has a prominent position on architect's desktop and pursues project's day-to-day schedules, goals and outcomes in an integrated manner delivering a green building in real sense.

2. BUILDING ASSESSMENT METHODS: A CAPABILITY STATEMENT

A green building implementation in true sense needs to identify its critical areas and monitor the progress against those identified areas, in other words measuring the environmental impact of design, construction and property management activities and the environmental impact of buildings (as products) (Crawley, 1999). The ambition to cover all the aspects of building design, construction and operation brings assessment tools in the forefront of green building support and such an encompassing range of considerations makes them eligible for a range of applications in building industry, although the intention of assessment tools might be varying depending upon the deferring priorities of developers.
A range of applications of environmental assessment methods is discussed by Crawley, (Crawley, 1999).

- Environment Management
- Product Marketing
- Building Performance Targeting
- Design Guidelines
- Performance based codes

- Environmental auditing in existing buildings

3. CONCEPTUAL PROJECT-ASSISTANT TOOL

3.1 Overview

A successful implementation of green design requires a vision that should be shared by each of the participant. Any building project involves a range of responsibilities, deadlines, coordinated tasks and scheduling and a loosely-weaved project plan can be detrimental to the prospects of a green product out of green principles. What is needed is to have a project assistance that, grounded in green principles, has a capability to draw together many strands of a green project.

The objective of these collaborative efforts is to make the `right' decisions, especially during the building design phases, when decisions have a long-lasting effect on the performance of the resulting building. (Papamichael, 2000)

However a need for a bigger environmental vision is necessary for an effective diffusion of anticipated end-use of assessment methods. It is envisaged that in their new role as a project-assistant tool, these methods will hold a brighter scope as an executable mode that by working under the umbrella of the broader organizational vision, executes that vision.

C-2000 program by CANMET Energy Technology Centre (CETC), Natural Resources Canada and concept of Environmental Management System are discussed here to appraise their suitability to provide the broader organizational vision and system.

3.1.1 C-2000 Program

The C-2000 Program for Advanced Commercial Buildings is a demonstration program for high-performance office buildings that leads the way to the design, construction and monitoring of buildings. The program was launched in 1993 and is experiencing a fair amount of success in Canada. Thirteen buildings have been designed, some of which have been built, while others are in, or approaching, construction. (Natural Resources Canada, 2001)
C-2000 follows goals of each of the three 'Program, Process and Performance' stages.
A team approach, advances in knowledge and technology transfers to builders, designers, equipment suppliers, utilities and operators of commercial buildings across Canada, are the highlights of this program. (Buildings Group, 2001)

3.1.2 Environmental Management System (EMS)

Concept of Environmental Management can be evaluated for the need of an organizational system. Environmental Management System is a systematic way of managing an organization's environmental affairs. An EMS follows a Plan-Do-Check-Act Cycle. Some of the key elements of an EMS are shown in table 1.
(NC Division of Pollution Prevention and Environmental Assistance, 2001)

Policy Statement
Identification of significant environmental Impacts
Development of Objective and Targets
Implementation
Training

Management Review

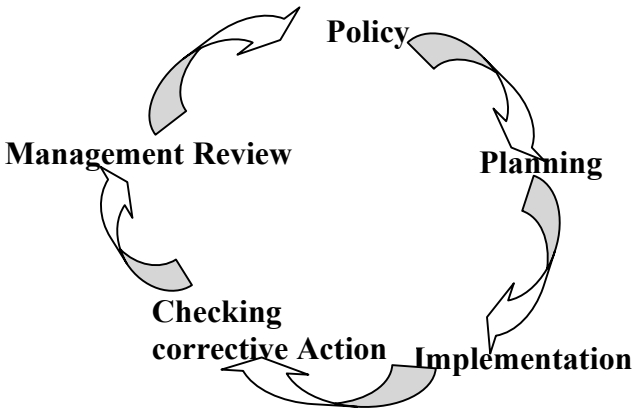

Table1: Elements of EMS

Figure 1: EMS Model

Source: (NC Division of Pollution Prevention and Environmental Assistance, 2001)

EMS offers a generic model that can be used and customized by a wide range of organizations whereas C-2000 is a pre-developed program that requires strong initiative from an organization for its successful uptake. For the purpose of this discussion the framework of EMS has been picked as the vehicle.

3.2 Outline of the Proposed tool

This paper proposes a mechanism that

- Deploys broader policies and principles of an EMS and
- Deploys a working tool as a subset of the EMS, that works in accordance to the principles of EMS and provides an executable mode to those principles and
- In addition incorporates features that compliment the Plan-Do-Check-Act Cycle.

Broadly a green-project assistant should be capable of followings-

- **Design Support: Identify the starting points of a green design (Plan)**
- **Project Management: Establish proximity with the day-to-day working of the project (Do)**

  -*Project Manager:* Such a system might also assist in keeping track of day-to-day record of goal-achievements, process responsibilities and task-schedules.

  -*Environment Manager:* Ensuring that the processes take place strictly in the environmentally responsive mode.
- **Decision Maker: Endorsement of the strategies selected by designers (Check)**
- **Reporting system:** for appraisal of the progress of work **(Check)**
- **Organizer and compiler (Act):** Offering to organize the coordinated tasks and integrated approach between project team members and offering compatibility to other employed tools and methods in a particular project.
-

By-Products:

- **Design Documentation:** Ensuring an excellent documentation of design as a by-product of the whole process, such documentation would not only facilitate post-occupancy evaluations but also make diffusion and promotion of such projects easier.
- **User-friendly interface:** An easy to use system and transparency of working is the most essential for an increased interest from the project team

4. HOW GB TOOL CAN FEED TO THAT CONCEPT

4.1 GB Tool as a principle

GBC'98 process, with a goal to develop, test and demonstrate an improved method for measuring building performance (Cole et al, 1999), developed a framework that incorporated a set of development principles. Few selected principles relevant to the discussion of this paper are given here-

- Establish a structure that can be used at various levels of detail, from broad-brush assessments to detailed ones.
- Establish a structure that, while suitable for immediate GBC 98 purposes, can also be subsequently expanded as a design guideline system, and
- Implement the system in a software system that will facilitate the work of making regional modifications and that will also simplify the task of inputting building data and assessing candidate building.

(Cole et al, 1999)

An ongoing improvement has seen GB Tool evolving as a comprehensive system that has and has been responding well to the critique, observations from national teams and other inconsistencies faced in the evaluations of test buildings.

4.2 GB Tool as a product

In retrospect of the roles and anticipated goals of Green Building Challenge, GB tool can be evaluated for its potential to feed in to the outline of project assistant tool. However all features might not entirely facilitate a different use of the framework. In order to function as a project assistant tool, the most crucial aspect is the appropriate implementation and integration of the features and capabilities of the tool with the project's processes in a manner that compliments the demanding nature of project management. Some of the favorable features are discussed.

Framework:

Powered with a very comprehensive framework and an extensive coverage of building design considerations, GB Tool gives a very recognizable and robust demonstration of environmental criteria. Owing to such a structure it can be said that GB Tool can effortlessly feed in to the environmental interests of any organization.

4.2.1 Additional Features

In addition to the undisputable structural ability of GB Tool, a number of features are discussed here that buttress its scope for the intended use.

- *Representative structure*

Structured to represent the contextual, regional and occupancy needs of the project, this attribute makes it very responsive to the variety of projects that organizations encounter. The four occupancy versions of the tool do justice to the disparity in the data types.

- *Technical platform*

The technical platform of GB Tool offers a great advantage in terms of its applicability, compatibility with other programs and to allow more add-ins to suit the need of the new role.

- *A thorough data input provision*

6 worksheets of data input give a great amount of liberty to restructure them for a process data input.

A collaborative process of 19 countries, GB Tool can be customized to make it country specific. Such an arrangement adds to its potential as an office tool in various organizations.
It is anticipated at this stage that with some modifications of the features and with extra add-ins, the tool can be given a shape of day-to-day tracking and management system. Suggestions are given after identifying some barriers of the tool.

5. THE BARRIERS TO THE NEW ROLE OF GB TOOL

The voluntary nature of the assessment tools has been a major obstacle in the wider uptake of building assessments. However making them mandatory also doesn't ensure their popularity, reason being the ignorance and inertia experienced by the users. But specific to the discussion of this paper, complex working of the tools is crucial. However the inevitable complexity due to the robust nature of the tool can be managed after a certain familiarity with the tool is ensured.
GB Tool also demonstrates few structural attributes that might be unsuitable for its uptake in a wider use. Some are mentioned here-

5.2 Complex structure: A very thorough framework might pose a threat to the ease of use that users demand. However it is also required to maintain a certain level of rigor in the process.

5.3 Assessor dependent mechanism: Isolated mechanism

As it is intended currently, different parts of GB Tool are meant to be used by different team members of the project, isolating the roles of different team members. For the final outcome, assessor assumes the responsibility. Such an isolated mechanism is not favorable to an integrated project working. However this isolation is only meant for a guiding step to the assessment process and can be restructured without much difficulty.

5.4 Inability to view quick decisions:

At some stage of the project, designers need to test their ideas for the environmental credentials and for that a transparency of working is recommended. Intended for a performance based building assessment, GB Tool doesn't visibly support a design process and is not designed to be transparent in terms of the associations between data-input and assessment outcomes.
However a restructuring of GB Tool might alleviate some of the barriers.

6. RECOMMENDATIONS:

As stated earlier also that in order to change the end-use, there is a need to overlay the features offered by the GB tool, the identified responsibilities of the project-assistant tool and the broader principles of the Environment Management System. A revamping of structural framework is also required but essentially keeping the same metrics, benchmarks and principles.
A further work on the elaborated criteria of a project-assistant tool would enable a better synergy of their roles and responsibilities. However some of the anticipated needs at this stage are as follows-

- A division of worksheet on the basis of a categorization that fits the responsibility structure of the team
- A real-time mode of the tool to facilitate a follow up of tasks and targets
- A system similar to Inspection Test Plan that highlights crucial activities and the responsible person, together with the crucial dates for that activity

- Different modes for serving different requirements such as a quick mode that enables viewing the outcome of decisions made by the project teams.
- Add-ins for reminders and scheduling to promote an integrated and coordinated approach amongst all the team members
- Connectivity to databases, standards and building codes
- A reporting system that generates weekly reports for appraisal of the progress of work
- A technical help and training support for the users

7. CONCLUSIONS:

In wake of the reactive, rather than proactive, nature of building industry, the need of green project assistance is highlighted. The scope of a tool that brings together all the strands of organization's environmental activities is discussed here.

The coupled action of an EMS and an assessment method is proposed to provide the required project-assistance. Capabilities and barriers of GB Tool are analyzed for the proposed tool.

A further research is suggested in order to refine and test the model that successfully diversifies the end-use of GB Tool as more than just a building assessment mechanism.

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What Environmental Data do Property Managers have on Buildings and their Management?

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INTRODUCTION

Context

Towards sustainable development, actors in the building sector have to handle a complex reality. Not only economic aspects, but also social and environmental aspects are important. Buildings' environmental impact is considerable during their use-phase, where property management companies are one of the key-actors. Among others, property management companies handle building related data, for example, they receive and generate data for operation and maintenance of buildings. Many property management companies have established quantitative environmental goals, i.e. measurable goals in form of aggregated numbers (indicators). Indicators, for example, energy used for heating [kWh/ m^2 floor area] or possibilities to separate domestic waste, illustrated an internal use of environmental data generated within a company.

Two ongoing research projects regarding:
a) existing building stocks and their environmental impacts (Thuvander 2000) and
b) environmental assessment of housing management (Brunklaus and Baumann 2001)
initiated the study presented in this paper.

Both projects consider existing buildings and management of them and they need data:
a) for testing a data base information system structure focusing on environmental aspects and
b) for testing an environmental assessment model of housing management with LCA and time series.

Thus, property management companies seem to be a source worth to be investigated in more detail to eventually meet the two projects data demands.

Aim and scope

The main objective of the paper is to examine and to discuss property management companies as a source to obtain environmental data on existing buildings and their management relevant to our research projects. By environmental data we address data such as use of material (building material, material used for maintenance, waste material), energy and water. Central questions of the study are

- What environmental data does property managers have?
- What time perspective does the existing data have?
- How do information flows look like and how is data documented?
- Does data suits the projects' needs?

Environmental data available in property management companies has been investigated by an *interview study*. Then, a list of desired variables resulting from our two research projects has been compiled and matched to the available data of property management companies. A more comprehensive description of the study can be found in Brunklaus & Thuvander (2002).

DATA OF INTEREST

Because of the two research projects different needs, data matching for both projects is required. One project needs data for testing a data base information system structure and the other project needs data for testing an environmental assessment model of housing management with LCA and time series. Evolving from these needs one variable list, valid for both projects, has been developed. Data of interest is environmental data addressing use of energy, material, water, generation of emissions, waste material, wastewater, etc (Figure 1). We do not consider embodied energy, i.e., built-in energy of the stock (from manufacturing of building material and assembling of the building). Data is organised in inflow data, outflow data, and built-in data (deposits).

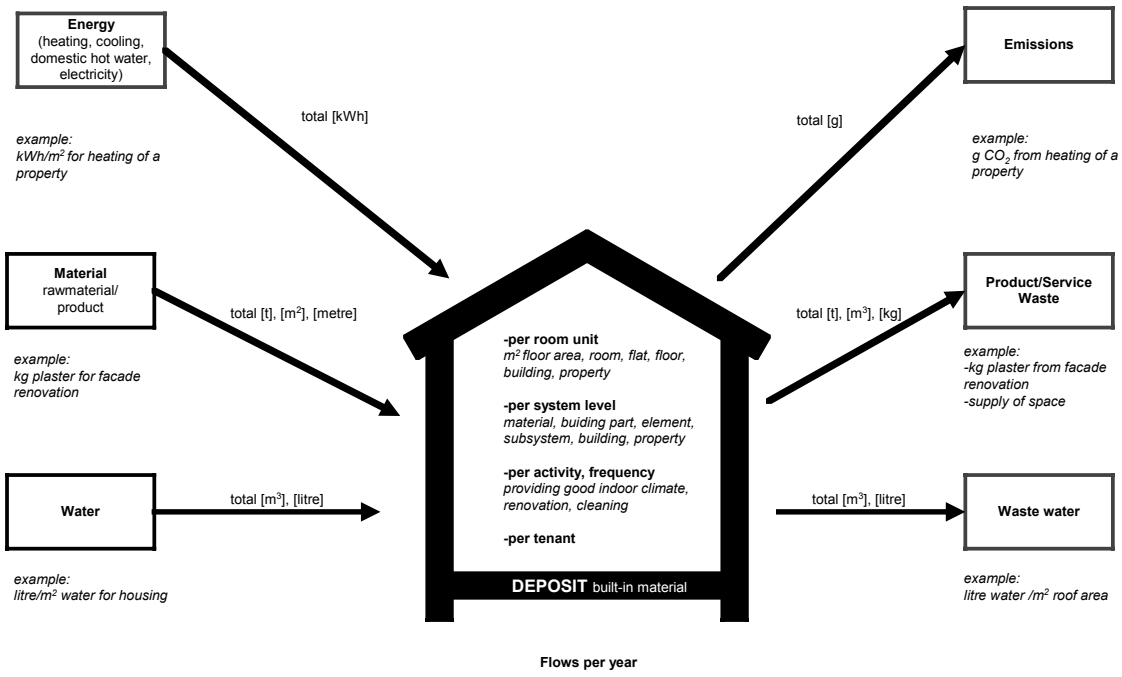

Figure 1 Compilation of desired variables resulting from two research projects.

Further, data descriptors such as time perspective on available data (measurement period), kind of measurement and access of data (direct or indirect), qualitative or quantitative data (occurrence or amounts), are used. These data descriptors illustrate the scope of data, i.e. are metadata (data about data). Metadata is important for the judgement of data quality, the relevance to our purpose (our data capture), and necessary when comparing data. Metadata is also an indicator for property managers' data control.

INTERVIEW STUDY

Property management companies were divided into the following categories: type of building stock they manage (multi-family housing companies and non-housing companies) and type of ownership (municipal, private, and tenant ownership). In each category representatives from property management companies in Göteborg and western Sweden were interviewed personally. Interviewees were people with knowledge of environmental data (environmental co-ordinator and technical director) or the head of the company. All together 12 companies were included.

Questions asked regarded *general aspects* such as

- organisation of the company (type, changes in the organisation, environmental activities)
- building stock managed (type, location, floor area, number of flats, age of the stock)

and more specifically *environmental aspects* such as

- occurrence of material data and energy use data related to new construction, operation and maintenance (including reparations and reconstruction)
- documentation routines (routines for measurement, storing of data, time perspective, access and use of data).

PROPERTY MANAGEMENT COMPANIES' ENVIRONMENTAL DATA

Environmental data found in the property management companies are presented below divided into characteristics according to Figure 1. Data similarities and differences regarding type of building stock and ownership are discussed as well.

Energy

During the use phase of a building, energy is used for heating/cooling and distribution of domestic hot water as well as for electric appliances, for example, ventilation, lighting, operation of lifts and laundry rooms. All interviewed companies, regardless their type of building stock managed or type of ownership, measure energy data for heating and domestic hot water (aggregated in one number). Differences exist in the time-perspective and level of detail. Municipal owners, for example, have longest time series on energy data (heating). For electricity, measured energy data differs between housing and non-housing companies. Thus, in housing companies, electricity data includes operation of common installations as for example laundry rooms, ventilation systems and lighting. Electricity use for flats is excluded. Among non-housing companies, divided subscriptions between tenant and property manager occur. Here, areas of responsibility are not always clear. Generally, data for electricity comprises a shorter time perspective than energy data for heating.

Table 1 Energy data – similarities and differences within the categories type of managed stock and ownership.

Similarities			
Type of data Measurement Time perspective	• Quantitative. All companies have energy statistics for heating and electricity • Direct. Data capture takes place monthly manually or automated • Electricity data up to 4 years back		
Differences			
Type of stock	***Multi-family housing***	***Non-housing***	
Level of detail Scope of data Activities	• Measurement heating energy per measure station, property, flat, or room • Electricity data well defined, flat excluded • Development of own energy statistic system	• Measurement heating energy per measure station or property • Unclear scope of electricity data • Development of model for calculation of expected energy use	
Ownership	***Municipal***	***Private***	***Tenant-ownership***
Time perspective	Heating energy data 10-30 years back	Heating energy data 2-3 years back	Heating energy data More than 30 years back

Material

During the operation phase of a building, various materials are used for maintenance and repairs, renovation, reconstruction, and to some extent for new construction. The material category scopes from chemicals, paints, wallpapers, white goods to building materials, such as wood, bricks, and concrete. Besides these inflows of materials, large amounts of material are already built-in in the stock. Outflows of materials are generated in connection with the above-mentioned activities and from demolition in the form of waste material. Also, tenants use materials and generate domestic waste. All studied companies record material data only to a limited extent. Measured material data is mainly data on environmental hazardous materials such as PCB, asbestos, mercury, heavy metals, radon, etc. Often it is data, which has to be collected because of legal regulations. Checklists are used to avoid the use of certain materials. Occurrence of a material is noticed, for example, when an environmental assessment method is applied. Thus, inflows are mainly controlled qualitatively, i.e., companies can make statements about a materials occurrence. Outflow data mainly regards abilities for sorting of building material and domestic waste, i.e. qualitative data. When buildings are demilished, demolition plans are established, which means an inventory of amount and kind of built-in material has to be carried out. In some cases, material data not measured can be reconstructed from economic data, i.e. bills, or calculated from drawings (both amount and occurrence). Domestic waste material is measured in different ways, amounts of waste and/or possibilities to separate biologic waste.

Table 2 Material data – similarities and differences within the categories type of managed stock and ownership.

Similarities		
Type of data	• Mainly qualitative data, few quantitative data (environmentally hazardous materials)	
Measurement	• Direct and indirect (environmental assessment tools, checklists, economic data, drawings, indicators)	
Time perspective	• Limited	
Differences		
Type of stock	***Multi-family housing***	***Non-housing***
Type of material	-	Handling of cooling agents

Water

Measurement focuses on inflow data, measured monthly and per property. In multi-family houses all use of water is measured (flat, common rooms, other tap places). In the non-housing stock only the water use for common rooms is measured; water use for industrial processes is not included. Amounts of water let to the waste water system, i.e. the sum of wastewater from activities in buildings and rainwater is not measured. In principle, all studied property management companies measure water inflows in a similar way.

Table 3 Water data – similarities and differences within the categories type of managed stock and ownership.

Similarities		
Type of data	• Quantitative data. Water inflows are measured, but no outflows	
Measurement	• Direct. Monthly per property	
Time perspective	• Between 1-4 years	
Differences		
Type of stock	***Multi-family housing stock***	***Non-housing stock***
Scope of data	Measurement of water use in common rooms and flats	Measurement of water use in common rooms excluding activity related water use

Documentation systems

In addition, documentation systems such as maintenance systems and drawings have been investigated because of their potential to function as a source for environmental data capture. Generally, information is stored in binders, digital reports, paper archives or databases. Paper documentation is the most common form. Energy statistics, maintenance systems, and archives for drawings are usually separated systems. Long-term planning for maintenance differs and is longer for the managers of multi-family housing stocks. Private managers have the shortest planning periods. In several cases there is no maintenance system.

Table 4 Documentation systems – similarities and differences within the categories type of managed stock, ownership and size of the company.

Similarities		
Measurement	• Indirect. All companies have systems for property data, maintenance routines and storage of drawings. Systems for structuring environmental information exist	
Documentation	• Paper archive for storage of drawings dominates, few use CAD	
Differences		
Type of stock	***Multi-family housing stock***	***Non-housing stock***
Time perspective	• Maintenance planning 5-10 years ahead	• Maintenance planning 1-5 years ahead
Planning system	• Several companies have maintenance planning systems	• Few companies have maintenance planning system
Level of detail	• Detailed documentation (room level), responsibility for whole building	• Documentation (if existing) on property level, not responsibility for inside of building
Ownership		***Private***
Time perspective		• Shortest planning ahead
Size of stock	Mostly companies owning ***larger stocks*** use CAD	

DATA MATCHING

The matching of the property management companies' environmental data to the list of desired variables (and by that to our project needs) showed that quantitative energy data are covered quite satisfying on different aggregation levels. Material data is mostly qualitative and scarce but it is possible to translate and calculate useful data from bills and drawings. Indicators such as exchange of tenants may help to calculate material flows because change of tenants usually is connected to renovation and reconstruction, especially in office buildings and shops. In flats, a high turnover may contribute to a faster wear and tear. Thus, high "turn-overs" of tenants would mean increased material flows. Qualitative data is better than no data, but unfortunately it is not always fulfilling our needs. Water data exists for inflows but out-flows of wastewater from the property to the sewage system are not measured explicitly. Data available can serve time series of good quality for energy data but only of insufficient quality for material and water data. Time perspective of data suffers from – beside of not measuring of data – from loss of data due to deficient information flows.

Table 5 Results from the matching study.

+	-
Good covering of energy data in different units	Little knowledge about materials and chemicals (more qualitative than quantitative data)
Possible to translate economic data into environmental data (both into quantitative and qualitative data)	No comprehensive data on wastewater from property
Knowledge about tenant change as an indicator for environmental effects	Not many data available for carrying out time series (water, electricity four years; heating energy ten years)

Data sources may be divided into *primary data*, i.e., data is measured directly, *secondary data*, i.e., data is measured but has to be translated (from costs or drawings), and/or *not measured data*. A primary source is energy data, a secondary source are indicators, documentation systems, drawings, environmental assessment methods, and bills. Not measured data are some material data, emissions/leakage from building materials or wastewater data. Energy data and water data are measured quantitatively whereas waste material is measured qualitatively.

FINAL COMMENTS

Besides data availability, accessibility of data is important for our projects in the perspective of data capture. Even if the property managers collect data of our interest, it is not sure that they will give us access to those. Concluding, property managers measure several environmental data of our interest and are a valuable data source. However, to get a more complete picture and a sustaining starting point for our research, deeper analysis is necessary by case studies of individual buildings and studies of other data sources, such as municipal actors or suppliers.

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raflatPrinciples of a sustainable urban structure

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1. INTRODUCTION

Essential factors of sustainability are linked with settlement densities. Many settlements show an uncontrolled growth accompanied by high waste of space, maximizing energy amounts, increasing traffic amount, increasing differences (eg. suburbs, outskirts) and effects like reducing local possibilities of purchasing and so on. It is necessary to gain understanding of the behavior as well as of the driving forces working in the settlement development.
Settlements must be seen as systems working after certain principles. Steering the development of settlements it is necessary to know the system behavior even regarding long periods. Similar to living systems settlements are restricted by limiting effects determining their optimal size. Further these systems underlie ecological and biological principles producing compensating effects and feedbacks.

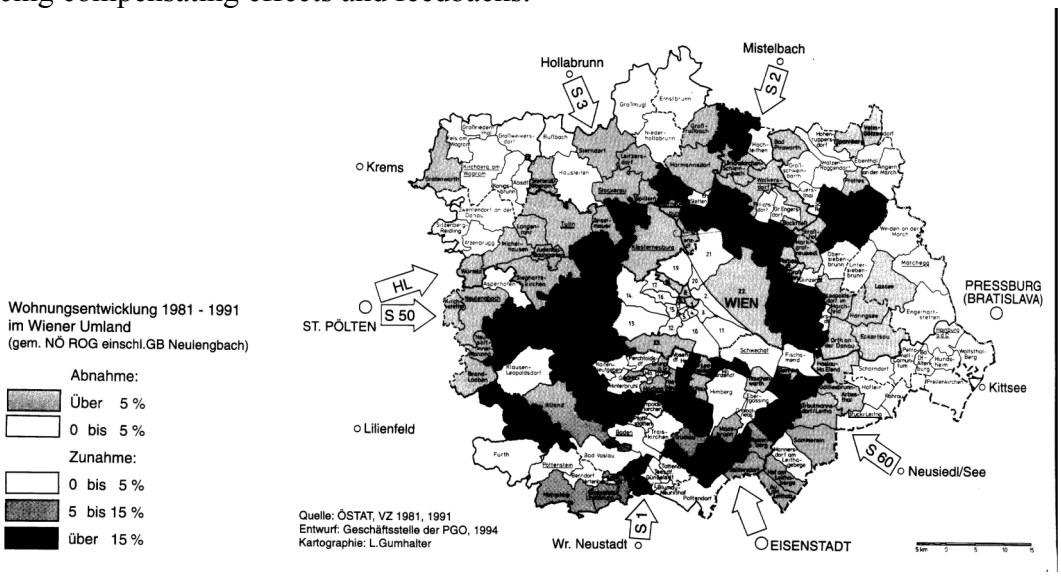

Figure 1 Housing development 1981-1991, Vienna outskirts, Source:STEP Wien

In reality many settlements show structures getting out of hand. As Figure 1 shows in Vienna like in other big cities there was a significant increasing of residences in the outskirts in the decade 1981 to 1991 (a still ongoing process). The driving forces behind that process are speed and saving time approaches.

2. SETTLEMENT STRUCTURES AND THEIR PROBLEMS

2.1 Feedback between dominant transport system and settlement structure

There are clear interactions between road network and settlement structures. The prioritarisation for motorized traffic with its high speeds resulted in a desintegration of

traditional “human-scale” urban functions. A car-orientated design of the road network especially in the outskirts of cities, lead to the phenomenon of urban sprawl.
This has then led to the demand for cities of short distances. On the contrary, however, development has gone into another direction.

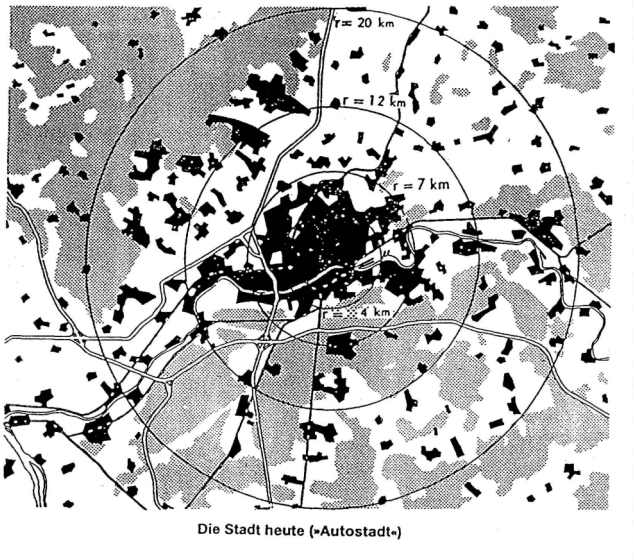

Figure 2 The changing city, Source: Wortmann W., (1995)

Like Figure 2 shows the expansion of settlement structure runs parallel with implementing new high-ranking transport systems as “backbone” of the settlement structure. These systems are usually in the initial stage faster than the older systems and they even are installed with the argument of time saving.
Human being however is mobile a certain time period a day out of genetic reasons so that there is no time saving in transport system by increasing speed. Increasing speed in contrary increase the distances, changes the city-structures and the economy, increases traffic problems and congestion, air pollution and accidents, shifts benefits to the big centralized structures and increases social disparities.

2.2 Connection between density (settlement structure) and mobility (Mode of Transport)
While the dominant transport mode influences settlement structure the settlement structures however determine the behavior. Obsercations found a clear connection in this respect. Vienna has a advantage analysing this research field because it shows a far-reaching concentric growth (compare Figure 1). The single areas were planned for different transport systems. While the City center (1. Bezirk) was designed by planners for abilities of pedestrians (distances, attractivity of street spaces, densities), the later built districts (Bezirksgruppe 2, Bezirksgruppe 3, -Figure 3) were designed regarding the possibilities of tram.
The outer district of Vienna (Bezirksgruppe 4) as well as the outskirts were created under the general conditions and possibilities of the motorized individual transport system.
As we can see within the City center about 30 percent of trips are done by car. This modal split is increasing with increasing distance from the city center up to a level in the outskirts of Vienna of 70%. The structures obviously determine the behavior of transport user and the mobility.

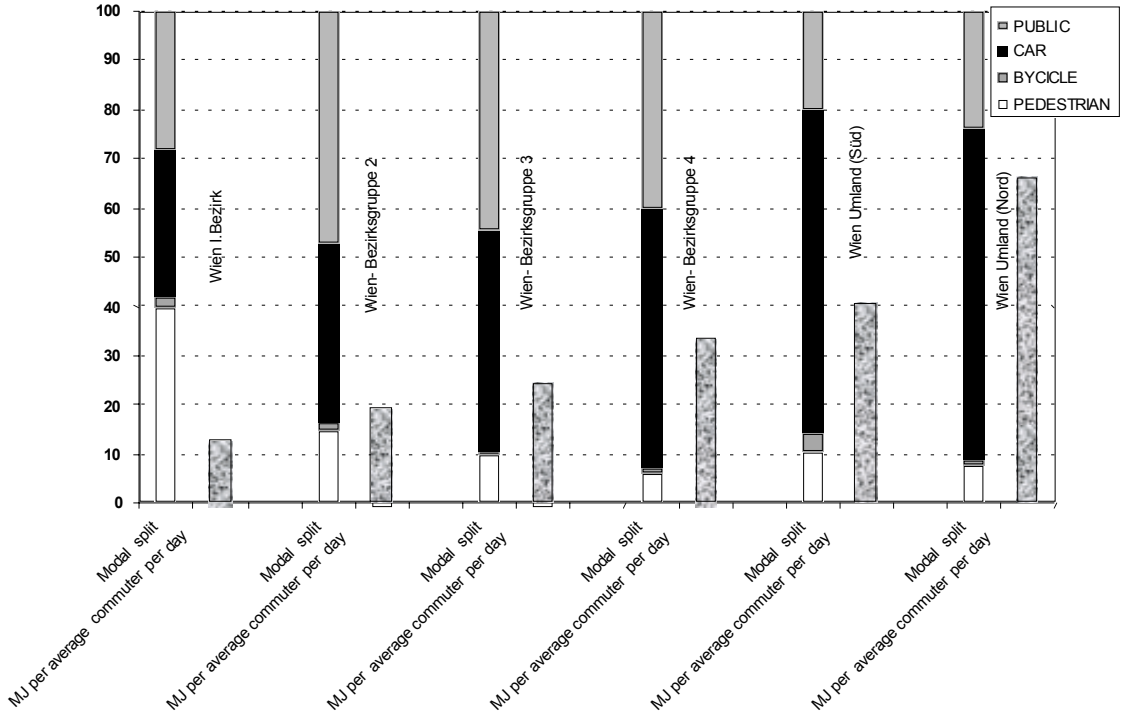

Figure 3: Modal-Split and MJ per average commuter per day for different groups of districts in different distances from Vienna city center, Source: Macoun (1999)

2.3 Biologic Background

Decreasing density of purchase opportunities, numbers of stops, working places, residences and so on leads to higher distances while fulfilling daily activities. This falling apart of different functions results in pedestrians and bicycles falling out of an optimum area of use.

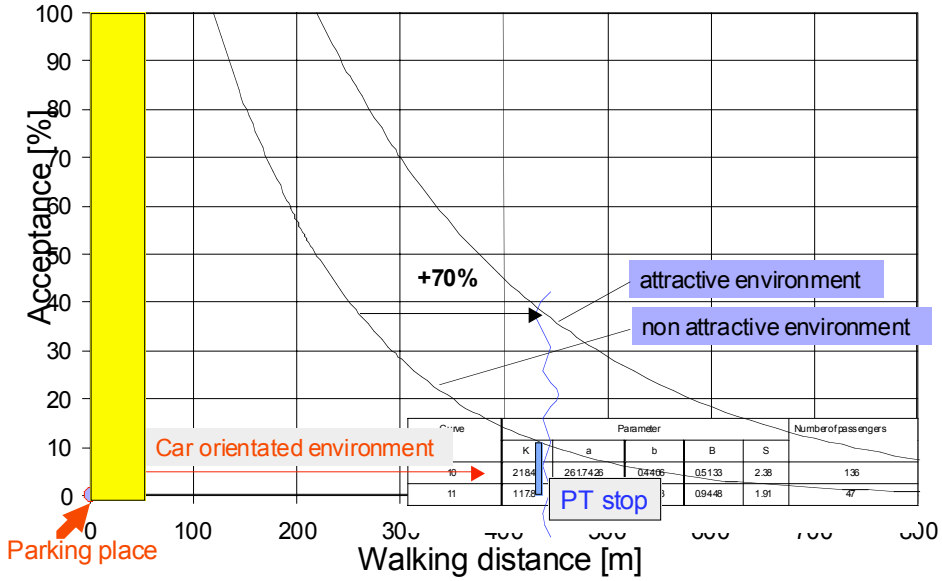

Figure 4 Acceptance of walking distances, Source: Knoflacher (1996)

The required deal of body-energy is decisive for the mobility behavior. Observations in Vienna showed that on average only 20 percent of pedestrian and cyclists are covering distances of more than 2 kilometers, while 80 percent of car drivers and public transport users are covering distances of more than 2 kilometers, 20 percent even more than 20 kilometers. As a result pedestrian and cyclists and by that human body-energy is keeping the settlement

structure together. It is necessary out of the point of view of the city-planners to take into consideration the possibilities of operation for these modes of transport.
Any trip is starting with a walk (to the parking place, to the bus stop). The acceptance of walking distances is therefore a crucial value. The negative exponential function (see Figure 4) explains oneself by the Weber- Fecher approch and the first law of thermodynamic. A parking place in a distance of 50 to 100 meters has a acceptance of 100%, a bus stop in a walking distance of 300 meter only a acceptance of 30 percent within a non attractive environment. Attractive environment for pedestrians increases acceptance for walking distances up to 70 percent.

3. PLANNING PROCESSES

3.1 Perception of Reality

Planning principles are mainly derived from theories as given in economy like economy of scale. Time savings and speed play a great role. (Time savings are also weighted high by transport system users). In fact all our observations show that despite of quicker transport systems the daily mobility time is constant since the last decades ("constancy of travel time") which is obviously caused by evolutionary drivers. Time savings as a main argument in the field of transport planning therefore is converted into longer distances. As a result of human beings having only senses for short periods these effects can not be perceived in the right way. In fact there are no time savings in real systems considering longer time periods. Similar to this problems of perception of time we also have problems perceiving space/distances despite walking them by foot and we have problems to realize causalities in a complex world system.
But there are some more problems of perception for human beings. One of them is the handling of differences (winner and looser of a measure), the realization of waste of energy (as far as it is not the own body-energy) and according to that we have problems of realizing borders of development. Settlements seem to have no borders but there are borders especially in a global contex. We can show these borders by approaches like the footprint concept by Wackernagel.

3.2. Conscious and unconscious parts of behavior and planning

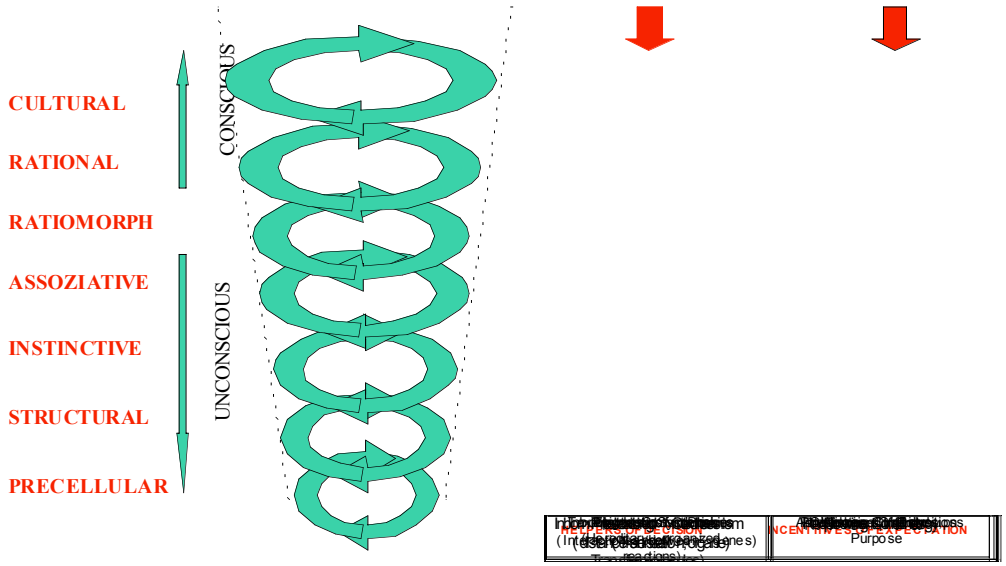

Figure 5 Levels of "helpers of decisions" and "incentitives of expectations" in a cycle of expectations and experience, Source: Riedl R., (1995)

Perception and Behavior also of planners and experts is the result of evolutional drivers forces. There are a lot of unconscious levels determining the "rational" acting human being. (see Figure 5).
Up from the precellular level which represents the flowing of (body-)energy and which is a mighty level to the assoziative level representing inborn releasing mechanism, the drivers are unconscious. The conscious level is in contrast to this a rather weak level.

3.3 Current Planning processes and principles

Following the named problems of perceiving reality and especially the borders of development the planning processes and targets are currently not sustainable. Travel time saving and other local effective criteria like noise, emissions or investment costs are weighted very high. On the other hands criteria like waste of space, loss of flora and fauna, waste of energy which are system-effects are still weighted very low.

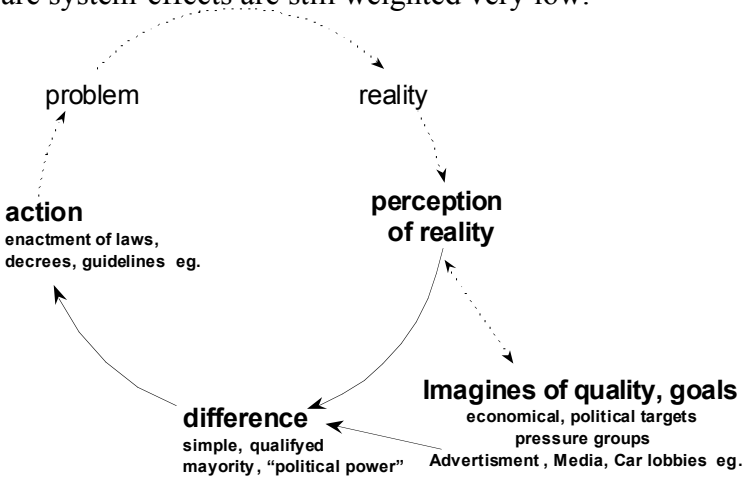

Figure 6 Cycle of acting in a planning process, Source: Macoun 2001 after Knoflacher

This is a result of the fact that humans perception is adjusted to short periods, slow changes, clear scales and small social groups. Out of human ecology approaches we know that there are also individual weighting mechanism by influenced by status, target and experience.
This has also effects on the planning process. We normally are not able to perceive the real behavior of a system. That means that we do not find adequate measures but we are forced to plan by a iterative process (try and error). The reason of acting on that occasion is a perceived difference between images of qualities and other targets and the perceived reality. There are of course great time delays, grasping a problem, finding a quorum (majority) to act and the lay down of new guidelines.

4. ECOLOGIC PRINCIPLES

In a complex system uncertainty and risks are very important terms. The poor perception facilities of humans as well as the missing possibilities of experiments in the social sector and the small time to react because of great time delays in the settlement and transport system forces us to draw conclusions out of the ecology.
To establish a robust system against disturbance from outside we have to install quick reacting interlocked feedback loops being able to avoid undesirable exponential developments. This means to aim at a greater maturity of a system (Vester 1988). The ecological systems show a high experience in installing sustainable systems and in working with development borders. If we look for analogies we find ecologically proven principles, such as

- cooperation (e.g. linked transport system),
- variety (equal opportunities to reach different modes of transport),

- minimize energy amounts and maximum efficiency (with highest efficiency as possible), closed material cycles (recycling, exhaust gases),
- regionalization,
- a high grade of information,
- self-control by negative feedback (externalities) and so on.

By using analogous principles of ecology for urban planning and building the „organism“ city we can make progress reaching sustainable settlements.

5. CONCLUSIONS

Sustainability is a expression of retaining a steady state. The obtaining of sustainability is an iterative process caused by the uncertainty forecasting behavior of the complex reality. One important part of the real system is the “system” human being. If we do not realize the mostly unconscious drivers of behavior of people and planners, we will not reach a sustainable structure of settlements.

The reasons behind lie in the biological and equipment of human beings. First of all, we have to realize that we are evolutionary used to measuring distances by the consumption of body-energy. That means that we have established natural borders for walking distances. On the other hand, we do not have the sense for the use of non renewable energy. By using that external energy, we loose any control because there seems to be no borders of accessibility. In fact, there are borders but they are not well perceived, and if they are perceived then these defined borders are given low priority.

Additional there are main problems of perception regarding time (no savings of time in the transport/settlement system), space (wrong representation of space), causalities (problems to realize system effects), borders (influential feedback of global borders into local measures), differences (realizing difference and their developments).

One example concerning the effects can be given by the amount of body-energy needed within the urban traffic system looking at the differences in acceptability between location of parking places and station location of public transport. As long as bus stops are situated further away from places of activities and residential area than parking places for cars, people are “forced” to travel by car in order to save body-energy. These “driving forces” of human behavior, however, are unconsciously influential in our choice of mode for travel.

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1. INTRODUCTION

Skanska Sweden is a business unit within the international Skanska Group, focused on construction of infrastructure, residential and commercial buildings. Skanska Sweden is the largest construction company in Sweden, with about 15 000 employees. As part of Skanska's commitment to sustainability, a strong focus area is adaptation of products and materials used in construction towards resource efficiency and minimization of hazardous chemicals. In order to achieve such a development, a number of changes in the operations of several individual actors in the supply chain, as well as in their interaction with other actors, are required.

How has Skanska dealt with the challenge of establishing efficient environmental management in a chain of actors that covers approximately 15 000 suppliers and subcontractors and 60 000 building products? Several means of evaluation and communication have been developed and implemented within the framework of the environmental management systems of Skanska Sweden - in order to ensure that both internal and external environmental requirements are communicated and followed up efficiently throughout the supply chain.

2. SUPPLIER EVALUATION AND COMMUNICATION

The purchasing function and Skanska Sweden's main suppliers is of crucial importance in order to ensure success in achieving the overall environmental ambitions of Skanska Sweden. Skanska Sweden thus promotes development of environmental management of our main suppliers including environmental product development and eco-labelling. It is also of importance to secure a high minimum level of environmental performance from suppliers that are identified as critical from an environmental perspective in certain selected projects.

In order to communicate the environmental requirements on suppliers and products to the suppliers, a web site called Miljöwebben, *"The Environmental Web"* (http://www.inkop-miljo.skanska.se) has been established by Skanska Sweden. The purpose of the web site is to serve as a tool for management of environmental supplier evaluations. The supplier evaluations are used to ensure that the suppliers of Skanska Sweden are aware of and comply with legal requirements as well as Skanska Sweden's minimum requirements on suppliers and their products. In addition, by giving suppliers an opportunity to comply with requirements beyond minimum requirements, and hence market themselves in terms of environmental

aspects, the intention is to stimulate suppliers to develop environmental management and provide incentives for environmental excellence among our main suppliers.
The result of the environmental supplier evaluation is then integrated into the total supplier evaluation performed by the purchasers, which also takes into consideration parameters such as economy, quality, time, technology and level of co-operation. As a result of the environmental supplier evaluation, the supplier will be placed in one of four categories of suppliers: Not Approved (level 0), Approved (level 1), Good (level 2), and Very Good (level 3). The questionnaire that is the basis of the evaluation is divided into three parts, of which all the requirements of the first part need to be met by the supplier in order to be approved.

The requirements of the first part mainly aims to secure compliance with environmental and occupational health legislation, and that the supplier complies with minimum Skanska requirements such as at-source waste separation at project sites, that products sold do not contain restricted substances and that the supplier will identify products that contain hazardous substances that Skanska has decided to phase-out. To become a supplier evaluated as Good, all the requirements of the second part of the questionnaire have to be fulfilled. These requirements entail for example that suppliers must work according to established environmental policy, targets and programs, which are followed up by documented internal audits. It is also required that environmental information in the form of Building Product Declarations is supplied for delivered products. To become rated as Very Good, for example means that the supplier needs to have implemented a certified environmental management system, that the supplier has in-house environmental specialists as well as reference projects with high environmental profile, and that the supplier provides products that fulfil criteria of environmental labelling where applicable.

The supplier answers the questionnaire on-line. The evaluation is later performed by an editor of the web-site, which is associated with the Environmental Unit of Skanska Teknik. The result is then communicated to the purchaser at Skanska that is the contact of the supplier. If requirements are not met, the purchaser has to support the supplier to improve in order to continue to co-operate. Otherwise, an alternative supplier has to be identified. The supplier can at anytime enter the web-site using his unique user name and pass word, and update his questionnaire. The supplier is able to view the result of the evaluation of his company, but not of the competitors. The latter information is only available when logged on as a Skanska employee.

The Environmental Web makes it possible to communicate general requirements and principles to a larger number of suppliers, as well as giving them an entry to ask questions regarding the requirements. At present, more than 700 prioritised suppliers have been evaluated through the Environmental Web, of which approximately 80% has been graded as Approved, 10 % Good and 1% Very Good suppliers. The information provided on the Web by the suppliers, is then used as a basis for a discussion of the suppliers' environmental performance held in the regular follow-up meetings held between Skanska purchasers and the suppliers.

3. PRODUCT EVALUATION AND COMMUNICATION

The Skanska in Sweden Product Evaluation Method has a strong focus on contents of hazardous substances in chemical products and other building products used in construction. The basis of the Evaluation method is the chemical substances lists, consisting of the List of

Restricted Substances, the List of Phase-out Substances, and the Surveillance List. Further, the method also includes criteria for recommended products.

The List of Restricted Substances ("Förbudslistan") is based on the Skanska Group list of five globally restricted substances, which for Skanska in Sweden has been extended to cover 15 groups of substances that are not allowed to be present in products purchased by Skanska in Sweden or any of its subcontractors. The restricted substances are primarily examples of substances which use is not in compliance with Skanska environmental policy or Swedish and international legislation.

The Skanska in Sweden List of Phase-out Substances ("Avvecklingslistan") is a list of 24 substances, or groups of substances, that are to be phased out from products purchased in the Swedish Skanska companies. The selection of substances is based on an analysis of which substances that are to be phased out on a short-term basis due to their especially harmful environmental and health characteristics, and their relevance to the building sector in terms of volumes used. Also this list could be seen to constitute a list of examples of substances that are to be phased out, as the intention is not to replace them with not mentioned alternatives which possess the same negative characteristics.

Skanska Sweden has established an environmental target associated with the chemical lists, which entails that by the end of the year 2004 no phase out substances should be present in purchased products. An exception is made for brominated flame retardants, which has been selected as a priority issue and which should therefore be phased out by the end of year 2002. For products covered by central and regional purchasing agreements, the time table is more strict, and the target is set such that no substances on the phase out list should be present in products through central agreements by the end of year 2002. Other examples of substances present on the phase out list are phthalates, cadmium, mercury, lead, chlorinated paraffines and nonylphenoletoxylates.

The Surveillance List ("Bevakningslistan") is a selection of substances that is given special attention due to their negative characteristics from an environmental and health perspective, but are for different reasons not currently selected for phase-out. Still, it is considered preferable to choose a product that does not contain any substances on the surveillance list than one that does.

In order to enable all parts of the organisation to comply with the product requirements and to be able to select products that do not contain phase out substances, two database tools have been developed: *"The Chemical Database"* (Kemdatabasen) and *"The Environmental Database for Building Products"* (Miljödatabas Byggvaror). The Chemical Database is available on the intranet and consists of more than 5000 evaluated chemical products used in Skanska in Sweden and their Material Safety Data Sheets (MSDS). Only products that have been subject to purchases are included.

All chemical products that are to be purchased or used within Skanska in Sweden have to be evaluated in the Chemical Database. If someone in the organisation intends to use or purchase a product that is not evaluated, the product's Material Safety Data Sheet is to be sent to the local environmental co-ordinator that performs an initial screening of the information and secures that the Data Sheet reaches the editor of the Chemical Database. The editor is an environmental specialist working at the Environmental Unit of Skanska Teknik, and who

performs the evaluation of the product based on the chemicals lists. A product that contains substances on the List of Restricted Substances is labelled as “Forbidden”, products that contain substances on the List of Phase-Out Substances receive the grade “Phase-Out”, and products that contain substances on the Surveillance List are evaluated as “Approved under Surveillance”. Products that do not contain any substances listed are simply “Approved”. Finally, certain criteria for products that are recommended, such as products with an official eco-label, are considered as “Skanska’s Environmental Choice”. If the quality of the information in the Material Safety Data Sheets is to poor, which is a decreasing but still common problem, this will also be a criterion for valuing a product as “Phase Out”. The latter has been an important driver for improved quality of provided information.

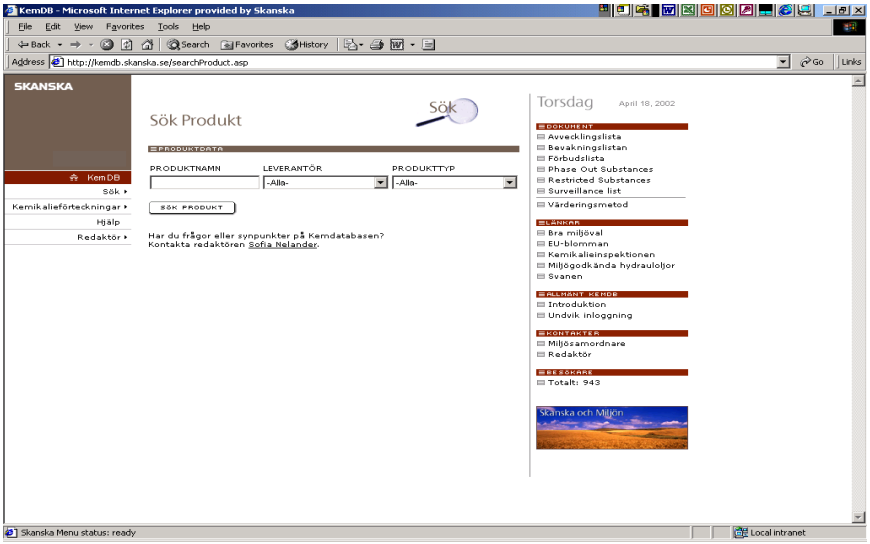

Figure 1 The Skanska in Sweden Chemical Database

The Chemical Database is equipped with a search engine, where products can be searched based on product name, supplier name or product type. Further, advanced searches based on for example substances, valuation, and date of Material Safety Data Sheet, can be performed in combination with other parameters. With each product item in the database, the associated Material Safety Data Sheet is available in digital format. The evaluation of the product is also followed by an explanation where the reason for giving the product as certain grade is given.

An important function of the database is also the possibility to establish and maintain site specific registers of chemicals used. Such registers are required by law, and keeping the register directly in the database is associated with many advantages. The register can be viewed by all persons associated with the project, and the right to update the register can be given to as many persons as is considered relevant. Links to Material Safety Data Sheets is placed directly in the database, and when the project is finished it is a simple task to save the register to a disk or CD and hand it over to the contractor - who is in a simple form given complete files of all chemical products used in the construction of the building.

Also, keeping site registers of chemicals in a common database provides a useful opportunity to get an overall picture and statistics of chemicals used in the organisation and assessments of how well this use corresponds to the set environmental targets and requirements.

Table 1 Chemical products in the Skanska in Sweden Chemical Database

	2001	2000
Total number of evaluated products	4749	3184
Skanska's Environmental Choice	71	40
Approved	2249	1415
Approved under surveillance	1540	956
Phase Out	878	765
Forbidden	11	8

As a complement to the Chemical Database, also The Environmental Database for Building Products is available on the intranet. This database consists of more than 700 evaluated complex building products (not chemical products) and associated Building Product Declarations. The database is used to provide evaluations and environmental information for such products that are not classified as chemical products, and thus are not covered by the legal requirements concerning Material Safety Data Sheets. Instead, the Swedish Building Sector has agreed on a common format for voluntary Building Product Declarations that are to be supplied with all building products.

Building Product Declarations contain environmental information such as material contents, resource use during production and use, end-of-life management, indoor emissions, and similar. These Building Product Declarations are used as the basis for evaluation of products such as flooring, insulation, and windows. The number of Building Product Declarations on the market is still limited. Similar to the Chemical Database, it is the organisation that supplies the database with its contents, and by doing so also makes the results of one project's efforts available to all the rest of the Skanska projects.

4. FUTURE REQUIREMENTS ON SUPPLIERS AND PRODUCTS

Several different trends that will effect the way suppliers and products are evaluated in the future can be observed. Firstly, it is likely that the increasing focus on corporate social responsibility, in combination with the increasing globalisation of the construction supply chain, will mean that the concept of environmental supply chain management will be broadened. Supplier requirements will to a larger extent also cover aspects such as human rights, business ethics and occupational health. This fact provides new challenges in terms of formulating, communicating and auditing such requirements.

Another development that is expected is an increasing complexity of product requirements. When it comes to requirements on product contents and use of chemical substances, the future development will require more knowledge on behalf of the suppliers. Focus will shift from phase out of a selected numbers of substances, to restrictions on all substances with certain undesired characteristics (such as carcinogenic, hormone disruptive, persistent and bio-accumulative substances). This will ensure that substances are not replaced by alternatives that are worse. It will also force producers to charge an overall responsibility to gain knowledge about the substances present in their products and to assess the characteristics associated with these. The development is also in line with the direction of future demands from the authorities concerning use of chemical substances, as pointed out in policy documents from the Swedish Parliament as well as the European Union. In order to enable also smaller market actors to comply with such requirements, it will be necessary to continue

to provide both suppliers and members of the Skanska organisation with tools that in a simple way communicates which products that fulfil the criteria.

For other product groups, where the environmental aspects are not associated primarily with material contents, an increasing focus is expected in terms of other product characteristics associated with our significant environmental aspects, such as suppliers' end-of-life management of products. The challenge here is to develop and communicate requirements that are targeted towards specific prioritised product groups. It is likely that a high degree of co-operation with the main suppliers concerning relevant requirements to be met will be part of the development. Demands will thus grow more complex, but also more specific and targeted.

5. CONCLUSIONS

Early on in the process of introducing environmental supply chain management at Skanska in Sweden, it became evident that it is important to provide supporting tools that enable the non-specialist to make environmentally sound choices of suppliers and products. As a consequence, Skanska in Sweden has developed a set of web-based databases that function as tools for evaluation and communication. The experiences of using the databases where environmental information of products used is provided, together with an evaluation against the product requirements at Skanska performed by a specialist, have proved that it is a successful way of empowering the members of the Skanska organisation. The databases have a high frequency of use, and are considered a simple way to secure that minimum requirements are met at the same time as more complex information for use in risk minimisation at specific project sites is provided in an accessible form.

The trends in future development of supplier and product requirements points towards a direction where requirements will become more complex in terms of what knowledge is required by the suppliers. However, requirements will also become more specific and targeted towards identified groups of prioritised product groups, that are considered relevant based on their influence on Skanska's significant environmental aspects. In order not to exclude smaller suppliers from the market, it will be necessary to continue the development of tools that communicate complex requirements in a way that is simple enough for all to use.

Experimental modelling of deciduous climbing plants as shading devices

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1. INTRODUCTION

This paper reports on the current progress and findings of research on the performance evaluation of a vertical climbing deciduous plant canopy on naturally ventilated buildings with respect to solar heat gain and daylight penetration.

In response to the issues of global warming, building designers, planners and architects are encouraged to introduce more sustainable building designs. One of the options is to use effective natural ventilation coupled with shading devices to reduce solar gain into buildings. Fixed angle metal shading devices have been widely used but they are normally designed for summer design conditions and do not make use of the winter solar gain. Variable angle solar shading devices are controlled in response to the weather conditions but they are expensive and complex for most building design. This paper introduces a bio-shading device which not only regulates the solar gains, but also improves the air quality as well as providing an aesthetically pleasing surroundings.

The use of plants growing directly on building facades has long been used and known for its thermal advantages. However in this research, the climbing plants are grown on a support framework external to the building facades and windows. This configuration complements many of the current 'bioclimatic' design of naturally ventilated buildings. Results from this research will provide the necessary performance data for the adoption of this design option.

2. RELATED RESEARCH

Bioclimatic describes an approach to building design which inspired by nature and applies a sustained logic to every aspect of a project, focused on optimising and using the surrounding environment. It is a common methodology used in the design of sustainable buildings. Some of the bioclimatic design objectives can be achieved by introducing plant growth covering the building fabric.

The use of vegetation to improve the building's microclimate has long been investigated by a number of researchers around the world. Although their methods varied, nearly all the results

confirmed that using vegetation around buildings could provide a better comfort for the occupants. Table 1 is a summary of the key experiments done by researchers in this field. Most experiments were related with climbing plants directly attached to building walls, some with inclined and horizontal sunscreens; one using deciduous trees and one using small potted plants. All results showed that solar radiation and temperatures were reduced with the use of vegetation.

Table 1 Summary of experiments and results for related research in bio-shading.

Author and year	Location	Type of planting	Wall-vegetation distance	Parameters measured	Results
Hoyano 1988	Fukuoka City, Japan	Horizontal wisteria sunscreen	N/A	Top and bottom surface temperatures of sunscreen	2ºC higher on the top of sunscreen
Hoyano 1988	Kyushu University, Japan	Vine sunscreen (35º inclined angle to the sun) on veranda	N/A	Veranda with and without vine sunscreen	Veranda without vine screen was 1-3ºC higher
Hoyano 1988	Tokyo, Japan	Ivy attaching and covering west-facing wall	Touching	Wall with and without ivy	18ºC lower with ivy covered
Di, Wang 1999	China	Ivy-covered wall at Tsinghua University	Touching	Ivy and wall temperatures. Wall with and without ivy.	Leaf temp was 8.2ºC higher than underneath wall temp. Leaf temp was 4.5ºC lower than that of the bare wall
Cantuaria 2000	London	Virginia Creeper covered on wall	Touching	Wall with and without creeper	Vegetated wall 10ºC lower than unvegetated
Ong, Lim, Chen 2000	Singapore	South parapet with potted plants	N/A	Parapet with and without potted plants	Parapet with potted plants was 4ºC lower
Papadakis 2001	Athens, Greece	Deciduous trees	Not mentioned	Wall with and without tree shading	Unshaded wall up to 600W/m^2 solar radiation, but 100W/m^2 on shaded wall

3. RESEARCH RATIONALE

As indicated in Section 2, most of the researches were focused on climbing plants directly attached to building facades. With such kind of arrangement, the climbing plants act solely as a cover to the wall which improves the thermal condition of the building interior by reducing heat gain and heat loss. This type of bio-shading design has its limitations in modern buildings. Nowadays, thermal resistance is much cheaper and easier to be achieved by thermal insulation in masonry walls, whereas plant growth directly on lightweight external curtain walls is not suitable in most cases.

This research proposed a bio-shading design with a supporting framework, constructed detached to the building facades and windows, on which deciduous climbing plants can grow on. This design provides several benefits. It can be applied to most building facades and allows easy access for plant maintenance. Apart from shading the solar irradiation in response to the seasonal weather conditions, the gap in between the plant layer and the building window also acts as a climate buffer zone. Air properties will be modified when passing through the plant layer, thus providing better air quality and lower air temperature in the summer.

Currently, there are very limited performance data available for this kind of prospective bioclimatic design. The current research therefore aims to provide the necessary design data for evaluating the performance of this bio-shader, the resulting indoor environment as well as the energy implications on thermal and lighting requirements.

4. PLANT SELECTION

4.1 Selection criteria

The integration of greenery onto contemporary architecture presents a novel design opportunity for designers and architects. When incorporating climbing plants external to buildings, the selection of suitable plant is very important. Table 2 shows a summary of the selection criteria that were considered in this research.

Table 2 Selection criteria of climbing plants for use as bio-shading devices.

Factor	Possible criteria	Selection criteria	Details
Growth rate	Slow, moderately fast, vigorous	Vigorous or fast	Limitation of research time for plant growth
Leaf size	Large, small	Large	Larger leaf creates large shading effect
Height climber can reach	High level, low level	Higher level	The higher the climber can reach, the greater coverage
Winter temperature tolerance	Fully hardy (withstand temp down to -15°C), frost hardy (withstand temp down to -5°C), half hardy (withstand temp down to 0°C) (Brickell 1999)	Fully hardy	Fully hardy plant can sustain through cold winter times
Maintenance	High, Low	Low	The frequencies of watering, pruning and adding fertilizers increase the overall cost. Lower these costs attracts designers and clients to adopt this kind of design
Orientation/ Sun preference	Full sun, partial shade, shade	Full sun	Full sun to act as shading device.
Weather tolerance	Costal, sheltered, windy etc.	High tolerance	Climber able to withstand adverse weather conditions
Types of soil	Sandy, coarsely, acidity, alkalinity etc.	Moist, humus-rich, loose-packed	Maintaining nutrients in the soil for climber to absorb will enable prosperous growth
Climbing patterns	Adhesive, twining, clinging	Twining or clinging	Climbing framework for the climber to grow on. So adhesive type is not suitable

4.2 Plants for the United Kingdom climate

This research will be done in the southern part of England where the average temperature is a few degrees warmer than most parts of the United Kingdom, with earlier springs, warmer summers and milder winters. The lowest winter temperature is rarely below –5ºC. There are constant onshore breezes with occasional strong winds. Taking the locality regional weather conditions and the criteria identified in Section 4.1, a number of possible climbing plants were selected. These are shown in Table 3 in order of their suitability to this research.

Table 3 Summary of climbers in order of their suitability for use as bio-shader in the southern part of the United Kingdom. Based on plant characteristics described in Brickell (1999) Chesshire (2001).

Species	Common Name	Evergreen/ Deciduous	Hardy	Climbing method	Height (m)	Growth rate	Leaf / Flower	Soil type	Pruning
Parthenocissus quinquefolia	Virginia Creeper	Deciduous	Fully hardy	Twining	6 to 12	Fast, tall and spreading	Very large 5-oval leaflets	Fertile/free-draining	Early spring
Polygonum baldschuanicum	Russian vine	Deciduous (Woody)	Fully hardy	Twining	5 m/ year	Very tough	Small chains flower	Any reasonable	Frequent
Parthenocissus tricuspidata	Boston Ivy	Deciduous	Fully hardy	Twining	6 to 15	Fast, tall and spreading	3-lobed leaves	Fertile/free-draining	Early spring
Wisteria sinensis	Wisteria	Deciduous	Fully hardy	Twining	Up to 30m	Rampant	Hanging blue flowers	Any reasonable	Summer
Vitis coignetiae	Vines	Deciduous	Half hardy	Tendrils	Up to 20m	Fast	Very large leaves	Free-draining, alkaline soil	Summer

The most appropriate climbing plant to be used in this research is Virginia Creeper. The unique ‘large 5-oval leaflets’ character makes it a good bio-shading device. Also it is tall, fast spreading, and requires pruning only in early spring. This is relatively more advantageous than Russian vine which requires frequent pruning due to its excessive rampant growth. The leaves of Wisteria are small and so shading efficiency is lower than Virginia Creeper. Whereas, Vitis Coignetiae is only half hardy which may not withstand the winter cold. On balance, Virginia Creeper is the best option.

5. EXPERIMENTAL MODEL

The main aim of the experiment is to measure the effectiveness of a deciduous plant canopy as an external shading device. The shading device applies to naturally ventilated buildings, in which air will be filtered through the plant canopy before entering the building interior.

5.1 Proposed physical model set-up

The proposed model is a single storey office building with room dimensions of 4m by 5m. The plant climbs on a metal framework as shown in Figure 1. A suitable container or trough will be used for the climber to establish. This trough will be placed on ground level of the building. Watering to the climber is supplied by an automatic watering system that responses to the humidity level of the soil. In order to minimise maintenance, appropriate type of fertiliser such as the time-release capsule will be used for feeding, so that only one feeding in a year is required.

Typical openable window area of 20% will be used. A gap distance of 600mm between the plant canopy and the building will be used to allow opening of windows and access for plant maintenance. Ventilation is facilitated by a variable speed fan situated at the opposite wall of the opening window (See Figure 1). This fan will be controlled by an external wind pressure sensor to simulate the fluctuation of airflow due to wind pressures. Table 4 summarises the other parameters used in the experiment.

Table 4 A list of parameters used in the experimental model.

Factor	Assumption
Room size	20m² (4m x 5m)
Number of occupants	2 people
Height of model	3.2m
Lighting load	15W/m²
Electrical heat gains	250W
Heat output per person	110W
Window area	4m²
Ventilation	Cross ventilation

5.2 Measuring parameters

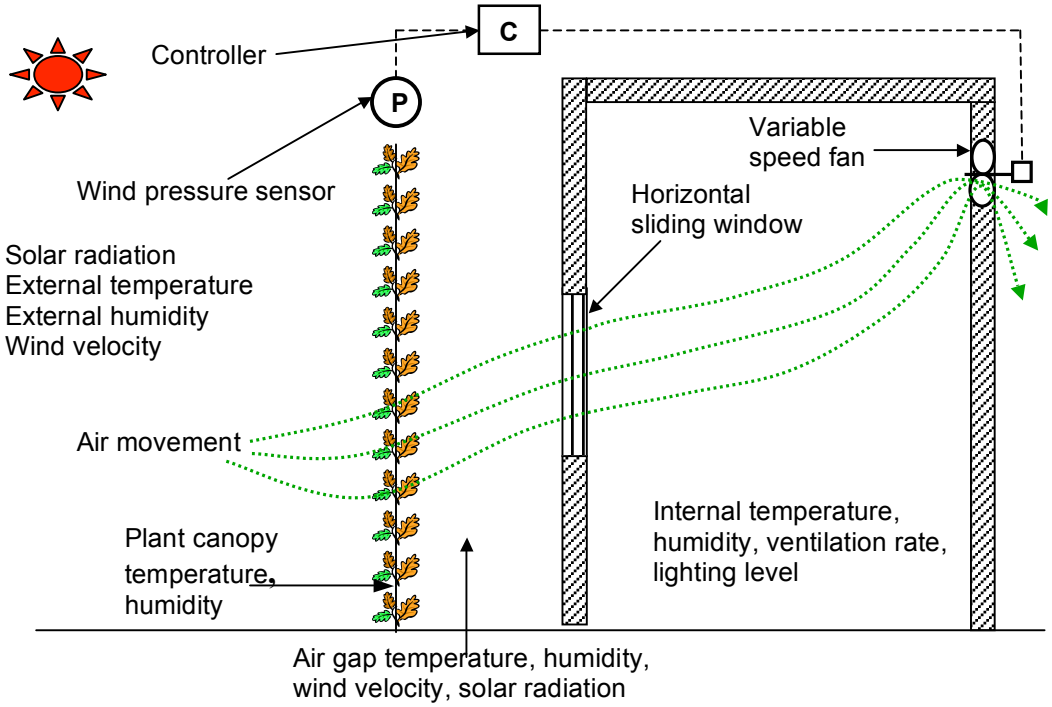

Figure 1 Preliminary experimental model set-up and measuring parameters.

Table 5 Details of the parameters to be measured.

Location	Measuring parameters
External surrounding	Solar radiation Air temperature Humidity Wind velocity
The canopy	Air temperature Humidity Plant coverage
The gap	Air gap temperature Humidity Wind velocity Solar radiation
Inside the building	Air temperature Humidity Ventilation rate Lighting level

The data collected from this experimental model will enable validation of theoretical thermal analyses as well as providing the necessary information for dynamic computer thermal simulation. The measuring parameters (see Figure 1) can be grouped into four categories:

a) External surroundings
b) The canopy
c) Gap between the canopy and the building facade
d) Inside the building.

Details of the parameters to be measured are summarised in Table 5.

6. PROGRESS AND CONCLUSION

A potential bioclimatic design based on an external bio-shader, making use of the natural growing characteristics of deciduous climbing plant has been proposed in this paper.

The first phase of this research has completed, concluding the selection of suitable climber to use and the design of the experimental set-up. A thorough review of other related researches has been carried out, and their limitations were identified. The review clearly showed a gap of knowledge in the understanding of how bio-shaders perform. Such understanding is necessary so that designers may be able to apply this kind of design. The next stage of the research is to construct the experimental model and to measure data necessary for the performance evaluation. The target outcome aims to produce easy to use graphical design charts as well as the database necessary for the dynamic computer thermal simulation software.

The proposed design is novel and the performance is expected to exceed current applications of direct plant cover on external walls. The magnitude of the energy impact is reflected by the results of an experiment measuring the cooling effect of ivy-covered wall, which showed a reduction of 28% of peak-cooling load (Di 1999). The proposed system offers not only summer solar shading, but also allows beneficial solar heat gain in winter. Moreover, it brings the much-appreciated aesthetic and psychological benefits to the building and its occupants. This research therefore plays a significant role in promoting a feasible sustainable design option; it also establishes the necessary design data for its implementation.

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EXPERIMENTAL MODELLING OF A SOLAR THERMAL STORAGE SYSTEM FOR THE SUSTAINABLE SPACE HEATING OF RESIDENTIAL BUIILDINGS

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1. INTRODUCTION

The domestic housing sector in the UK was accountable for 29% of the country's total final energy consumption in the year 2000, resulting in 23 million tonnes of CO_2 emissions (National Statistics. 2001). Of the total consumed energy only 0.4% came from renewable sources (National Statistics. 2001). The utilisation of renewable energy offers vast potential for reducing CO_2 emissions in the domestic energy sector. Solar energy provides a free, clean and renewable source of energy with low external costs, which are often ignored when comparing them with other forms of energy, nuclear for example. A barrier to the effective use of solar irradiation is its availability which is unpredictable, intermittent and variable. A domestic space heating system has been proposed that uses a phase change material (PCM) as a solar thermal storage medium, which can address the mismatch between solar availability and demand.

2. THERMAL STORAGE

There are two main types of thermal storage, sensible heat storage (SHS) where thermal storage occurs as a result of an increase in a material's temperature, or latent heat storage (LHS) where thermal storage occurs due to a change in a material's physical state. Materials that are used to store latent heat are commonly referred to as phase change materials (PCMs). Although SHS has been used for centuries in buildings for passive solar storage it does have some disadvantages. If SHS is used larger quantities of storage medium are required to store the same quantity of energy when compared to LHS, due to the fact that it requires far more energy to change a material's physical state than to change a material's temperature. This is illustrated by the fact that it takes 80 times more energy to melt 1kg of ice than it takes to raise the temperature of 1kg of water. It is this high volumetric storage density offered by PCMs that makes it possible to produce smaller and lighter thermal storage devices. A further disadvantage with sensible heat storage is that it requires a change in temperature in order for energy to be stored, which can result in undesirable temperature fluctuations. This situation can be alleviated if PCM storage is used in that heat storage occurs isothermally, which not only improves occupancy comfort but when used in conjunction with solar collectors can also

improve their efficiency (Lane 1983). This has been illustrated in Japan where in some regions temperature fluctuations can be undesirably low at night and uncomfortably hot during the day. It was found that by incorporating a PCM into the floor of a house, temperature fluctuations could be mitigated (Hokoi and Kuroki 1997).

3. PHASE CHANGE MATERIALS

There are two main types of PCMs - inorganic such as calcium chloride hexahydrate and organic such as paraffin wax. Although most inorganic PCMs offer high latent heat per unit weight and volume (Goswami et al. 1995), they have two major drawbacks. Firstly they suffer from supercooling (Lane 1991), which can make it difficult to retrieve stored heat and secondly they degrade over time (Dincer and Dost 1996). An organic PCM was selected for use in the current study because they do not suffer from supercooling or degrade over time (Jotshi et al. 1992) and so are able to offer consistent long-term stability in conjunction with high storage densities. Mixtures of PCMs such as Eutectics were not considered as suitable commercial products are not readily available.

4. PROPOSED SYSTEM

The current research builds upon the foundation of previous work carried out by Ip (Ip 1998) at the University of Brighton where a solar space heating system incorporating a PCM was proposed and analysed. Seven different system configurations were analysed using a dynamic computer simulation model. The simulation results indicated that the use of such a system had the potential to produce energy savings in the range of 18-32%.

The proposed system is a combi-system in that it is able to contribute to the space heating demand in the winter and the hot water demand in the summer, therefore it has the potential to reduce CO_2 emissions all year around. The system as illustrated in Figure 1, consists of a solar collector array, a highly insulated storage tank and a number of interconnected PCM filled metal panels. The PCM panels can be located either between floor joists, in a suspended timber floor or on top of a floor slab and boarded over. The panels are connected to one another using 15 mm copper tube. The PCM panels are constructed from aluminium sheet and measure 1000 mm long 360 mm wide and 90 mm deep. Each panel contains three compact heat exchangers connected in series as illustrated in Figure 2 and these are immersed in the PCM.

The design of the system has taken into consideration factors such as the ability to be installed in both new build and retrofit applications; addressing the problem of PCMs becoming self insulating materials and reuse of the system if the building it is in becomes decommissioned.

4.1 System Operation

During operation water heated by the solar collector is pumped through the heat exchangers in the PCM filled panels, which causes the PCM to melt thus storing this thermal energy as latent heat. When space heating is required the PCM is allowed to solidify thus releasing its stored latent heat. During the summer, water heated by the solar collector can be used to meet the household hot water demand.

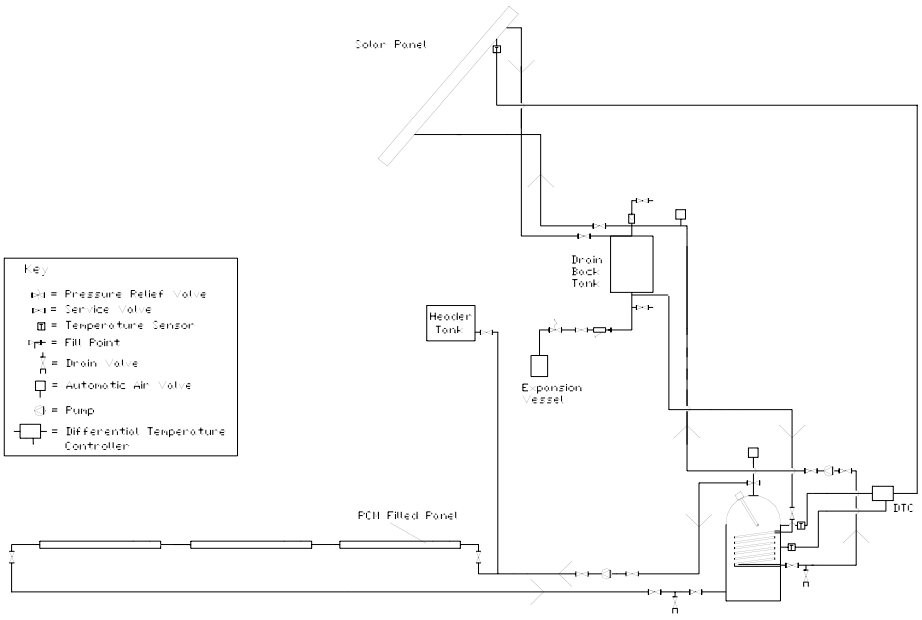
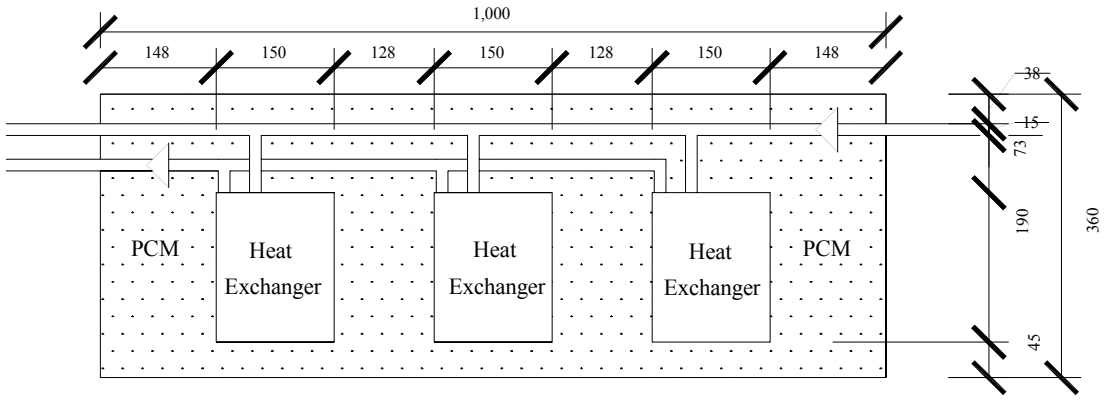


Figure 1 System Schematic



Plan View Of PCM Panel With Lid Removed To Show Heat Exchanger Layout

Figure 2 PCM Filled Panels

5. EXPERIMENTAL MODELLING

Phase change materials are notoriously difficult to model mathematically due to the fact that it involves solving moving boundary problems (Cheng 2000) (Hasnain 1998). Where solutions have been proposed they tend to be very case specific so unless the same system is used they are difficult to apply. Other problems with mathematical modelling are that assumptions made by authors such as neglecting the effects of convection (Buddhi et al. 1988), or the PCM melting at a constant temperature (Roy and Avanic 2001) render them unrepresentative of the real life scenario. An experimental approach is therefore necessary for the reliable study of the performance of the proposed system.

5.1 Scale Model

A highly insulated test box illustrated in Figure 3 has been constructed at the University.

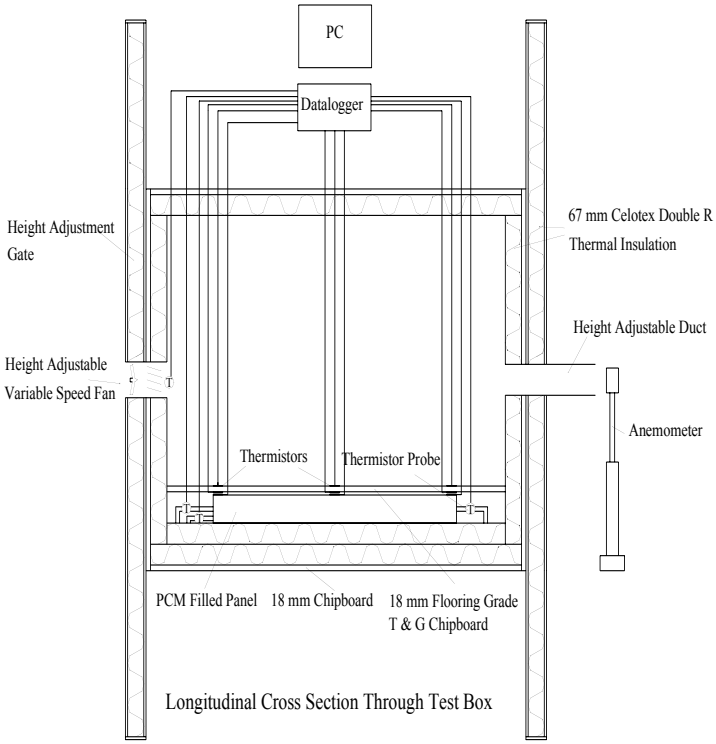


Figure 3 Test Box

The box has been designed to replicate similar conditions that would exist if the system were installed in a real life building. The floor can be changed between suspended timber and solid slab in order to measure the affect that the floor system has on system performance. On one side of the box a fan adjustable for height, is used to direct air into the box and baffles used to alter airflow through the panel. On the other end of the box there is a height adjustable duct that allows air to exit the box and a hot wire anemometer will be used to measure air speed and temperature.

A full size PCM filled panel has been constructed using aluminium sheet and three compact heat exchangers connected in series within the panel. The panel is filled with 24 kg of Rubitherm® RT40 PCM, with a melting point of 42.8°C. The desired melting point of the PCM was calculated by starting off with the maximum surface floor temperature that could be used whilst still maintaining thermal comfort which was taken as 27°C. Heat loss calculations have been carried out in order to calculate the temperature of the PCM panel required to achieve the desired surface floor temperature. The calculations showed that a panel temperature of 41.2°C could produce the desired surface floor temperature if used with 8mm plywood, or 46.2°C if used with 18mm plywood. The calculated desired melting point correlates well with previous research using PCMs to provide space heating (Farid and Chen 1999).

A selectively coated flat plate solar collector with an area of 4.22m^2 was kindly donated by AES Solar Systems Ltd based in the UK, for use in the project and has been installed on the roof at the university. It uses a drain back tank to provide freeze protection, which is essential in the UK, and a differential temperature controller (DTC) controls its operation. The panel is orientated towards true South at an angle of 50° to the horizontal so that it can capture higher amounts of solar irradiation in the winter months when it is most needed.

A cup anemometer to measure wind speed, pyranometers to measure direct and diffuse solar irradiation and a linearised relative humidity and ambient air temperature sensor have been installed on the roof in the same location as the panel. These instruments will provide data about the microclimate that exists around the solar panel and its affect on its performance.

6. DATA ACQUISITION

Thermistors will be used to measure the temperature of the floor surface, the underneath of the floor surface, the top of the PCM filled panel and the bottom and sides of the PCM panel. Temperature probes have been inserted into parts of the copper pipe work in order to measure the flow temperatures at certain points in the system. The probes are located in the feed to and from the solar panel, the feed to and from the solar store, and the feed to and from the PCM filled panel. An optical flow rate sensor has been installed in the hot water feed to the PCM filled panel and also in the return feed to the solar panel. The outputs from the thermistors will be fed directly into an Agilent 34970A expandable datalogger, as will the data from the water temperature flow sensors. The output from the flow rate sensors will be fed firstly into a control box for signal conditioning before going to the datalogger. The output from the anemometer, pyranometers and relative humidity and temperature sensor will be fed directly into the datalogger.

6.1 Data Analysis

Heat output curves for the solar panel will be produced using the thermal data gathered in conjunction with the weather station data. The collector loop efficiency will be calculated along with the PCM panel efficiency and the amount of thermal energy delivered to the space heating system.

Analysing the data collected will produce five key outcomes:

1. Solar panel performance (including system losses)
2. Charging and discharging cycle
3. Energy transfer – water side
4. Energy transfer – air side
5. Performance curves of the PCM panel at different water temperatures, water flow rates, air temperatures and air flow rates

Once the thermal performance of the PCM model has been measured this data will then be used in a thermal simulation programme in order to evaluate the potential energy savings the use of such a system in a domestic application can offer. The model will be based on a three bedroom house located in South East England. The use of a thermal simulation programme means that parameters such as location, orientation, construction and size of apertures can all be easily incorporated in order to study the system performance representing a real building.

7. CONCLUSION

A solar thermal storage system using a PCM for space heating has been proposed that has the potential to reduce energy use and hence CO_2 emissions on an all year round basis, helping in the long overdue move towards sustainable development. The data collected from this experimental measurement will provide the thermal performance of a modular PCM panel suitable for underfloor application in a domestic building. The research will provide valuable performance data that can be fed into system design simulation software for the assessment of annual space heating energy use of a building. Such design tools and data are essential for designers wishing to incorporate PCM storage in dwellings in order to provide space heating.
The research will also generate real life performance data for a flat plate solar collector and the affect that environmental conditions have on panel performance. The outcome of this research will enable the implementation of a novel sustainable space heating system for use in domestic buildings.

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Transparent and sustainable buildings

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1. INTRODUCTION

In 1914, at a time of social conflict and revolution in Europe, the German visionary writer Paul Scheebart described his dream of a world revivified by glass architecture:

If we want our culture to rise to a high level, we are obliged for better of for worse, to change our architecture. And this only becomes possible if we take away the 'closed' character from the rooms in which we live. We can only do that by introducing glass architecture, which lets in the light of the sun, the moon, and the stars, not merely through a few windows, but through every possible wall, which will be made entirely of glass.

This vision influenced and still influences most architects. Unfortunately, most of the architects still consider daylight transmittance as the only criteria for selecting glass. Since Paul Scheebarts' vision, the world has faced industrial revolution with increased and accelerating energy demand. The consequences of which are high energy consumption and thus high levels of greenhouse gas emissions.

Buildings account for about half of the world's energy consumption. Of all the activities of man, construction, directly and indirectly, has the widest impact on the environment. Architects and the whole construction sector should be more aware of their global environmental responsibility and make a serious attempt to find better solutions than at present. The glass industry has been aware of the advantages of glass but also of its negative impact on energy consumption and thermal comfort. Therefore, the glass industry has invested billions in product development and come up with glass that provides daylight transmittance, thermal comfort and energy efficiency.

2. GLASS IN BUILDINGS

2.1 Glass design

Designing and engineering with glass is still a poorly understood area of expertise amongst most architects and engineers. Good glass engineering takes the aspirations of architects and aesthetic designers and turns them into build-able components that make the best use of what suppliers have to offer. All glass types cannot be bended, toughened or laminated. Glass facades must resist thermal stress, wind loads and other loads etc.

WSP is an international business providing management and consultancy services to the property, land and construction sectors. We have long experience from glass in buildings and in design of double skin facades. Our office is involved in a number of projects in which the aim is to use more sustainable design and construction solutions.

The WSP Environmentals' consistent selection criteria for glass are that people will have the feeling that they work and live in a healthy, light and comfortable building.

2.2 Glass types

Three types of glass have mainly been used in glass facades in the past fifty years: Clear glass, body tinted and enamelled. Body tinted glass is produced by small additions to the melt of metal oxides, mainly iron, cobalt and selenium which add a shade of bronze, grey, blue or green to the glass. The tint makes the glass more heat absorbing. Enamelled glass is glass coated with opaque materials.

Today, the choice of glazing systems is wider than ever before. Many options are available to extend the degree of thermal, acoustic and visual comfort. New coating methods have improved the glass performance for solar heat transmittance, the glass U-value and the daylight transmittance.

3. CLIMATES AND ENERGY EFFICIENCY

Sustainable buildings with double skin facades should be designed to minimise energy consumption and thus reduce greenhouse gas emission. Glass design and glass choice have big impact on energy consumption for lighting, heating and cooling. They also have impact on the occupants well being, their health and their productivity.

Some architects particularly from southern Europe, claim that buildings in warm climates need different type of glazing than buildings in cold climates. A research carried out by the Lighting Research Unit, School of Architecture, University of New South Wales in Australia showed that energy saving is possible using energy efficient glazing even in hot climates.

In Sweden overheating in both residential and non-residential buildings is becoming a problem in buildings with large glazed areas. Particularly in spring and autumn, when the sun rays hit the glass from a low angle, overheating becomes a problem. Therefore, the use of high performance glass with low g-value (solar heat gain) and low U-value is increasing also in the residential building sector.

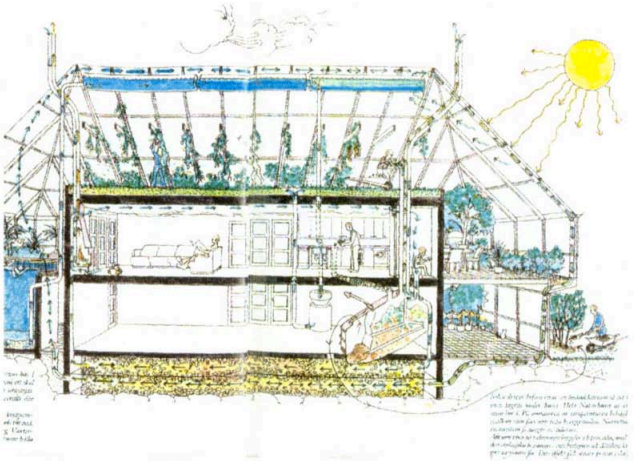
I participate in a EU SAVE project concerning energy rating of windows. Experiences from this project show that many southern European countries have several climate zones divided into winter zones and summer zones. We sometimes forget that you can ski in France, Italy and Spain or that the sun shines is up 24 hours per day in northern Sweden.

4. DOUBLE SKIN FACADES

4.1 Long experience

Double Skin Facades are not a novelty. In Sweden we have since thirty years what we call a 2+1 window. It is a window consisting of a double sealed unit on the inner frame and a single glass pane on the outer frame. It is popular because it allows Venetian blinds in the cavity.

The first double skin building was, as far as we know, built 1976 in Stockholm, Sweden by architect Bengt Warne. It was a traditional pre-fabricated one-family house encapsulated with clear glass. The indoor comfort was very good and this project was followed by many other similar projects in Sweden and abroad.





Pictures 1 and 2: The Nature House, Stockholm. Architect Bengt Warne.

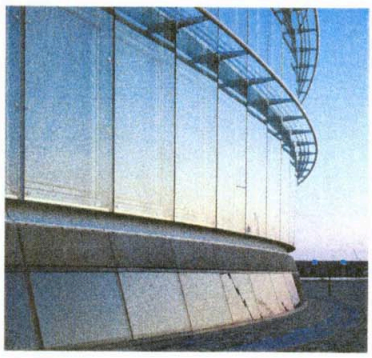
Another early double skin façade is an office building in Farnborough built in 1980. The reasons for a double skin façade were reduction of traffic noise and thermal comfort. The building has natural ventilation and a heat exchanger. Maximum measured indoor temperature summer time is plus 25 degrees Celsius and the lowest temperature wintertime is 18 degrees Celsius.

4.2 Recent projects

I have studied several projects with double skin facades. They all have some good solutions; some are a technical masterpiece with very complicated systems for ventilation whilst others have very simple solutions. Not many of the cover all criteria for a sustainable glass building.

Midtermolen, Copenhagen is the office of the insurance company Alm. Brand. Built in 1994, it is one of the oldest buildings with double skin facades in Denmark. The outer skin consists of a single glass pane with body tinted (green) glass. The inner skin consists of open-able windows with a double-glazing unit with low-emissivity glass. The air gap between the panes is only 300 mm and all cleaning of inner glass panes is done from the room side. The total U-value of the glass is 1,0 W/m2K. The light transmittance is 60 % and the solar heat transmittance 37 %.





Pictures 3 and 4: Alm. Brand head office, Copenhagen

It is important to look at the allocation of the coated glasses and not only at the total g-value.

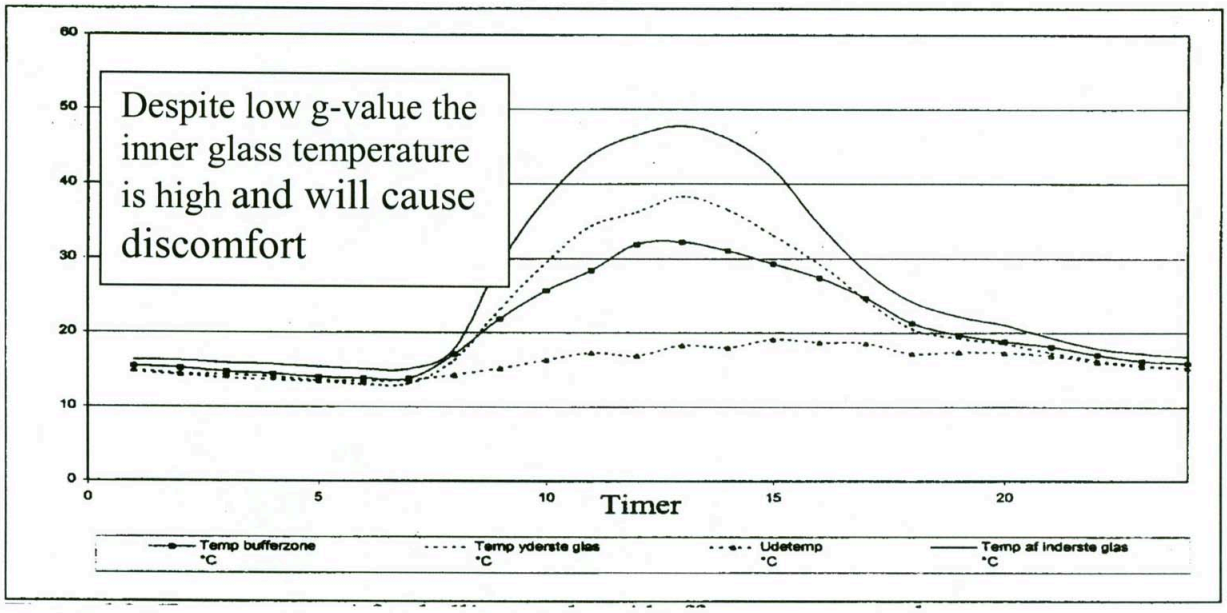


Figure 1

Another insurance company has chosen double skin facades for its new office building completed in 1998. Victoria head office is located in Düsseldorf and has clad its 29 storey tall building with 8.000 m2 double skin façade. The external wall consists of 10 or 12 mm single glazing with double glazed windows functioning as individual ventilation boxes.



Picture 5

The air gap has also power operated aluminium louver blinds. The building is ventilated with natural ventilation and lacks air-conditioning. This saves half million Euro per year and is equivalent to 16.000 tonnes of CO2 emissions.

5. COSTS

"Global warming is an important issue but it is not our immediate concern" are comments I often hear. What property owners and builders understand are costs. Reduction of energy demand means lower operational costs. Reduction of installed systems for heating, cooling and ventilation means also lower costs which brings us to why double skin facades are becoming more popular.

Avoiding installation of air conditioning covered the higher investment costs for the Victoria double skin façade. The higher investment costs for the thermo-electric plant have reached break-even after three years. The heating costs have been cut down by almost 50 %.

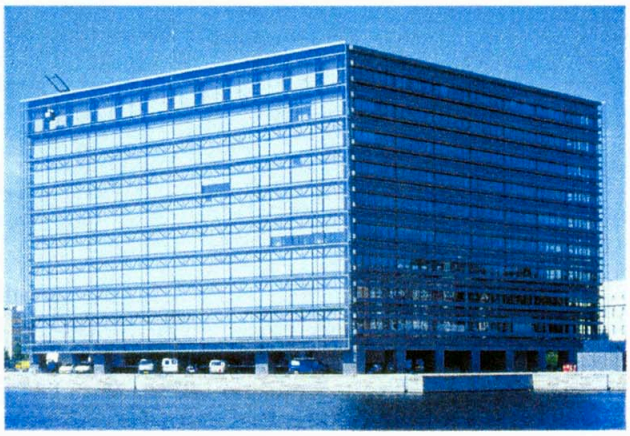
In Sweden, there is an interest for building double skin facades. It is difficult to say if it is because these may save energy or because it is a new trend. The market, that is tenants and staff, show an increasing interest in energy saving and in ecological constructed buildings Unfortunately, many of the projects are put aside because consultants and contractors are very conservative and reluctant to try something new. They doubt that natural ventilation will meet the thermal comfort requirements. Investors believe that double skin facades are expensive and risky. They are right if the project is not designed as a sustainable building with natural ventilation and low energy demands for operation. The cost for the "second skin" is not calculated on Life Cycle Cost basis taking operational and maintenance costs into account. Calculations from realized projects show that where there has been a good planning with focus on energy efficiency, the costs for the total building have not been higher than those for a conventional building.

6. SOLAR HEAT

Total energy transmittance through glass is divided into transmittance T, Absorption A and Reflection R. Transmittance is separated into direct solar transmittance and indirect heat transmittance. The indirect transmittance is part of the heat absorbed by the glass and long wave heat from surroundings (buildings, plants, soil). High performance coatings stop not only the short wave solar radiation but also long wave heat radiation.

The major problem in a double skin façade building is excess heat. It is five times more expensive to lower indoor temperature by one degree than to increase the temperature by one degree. Still, the architects demand glass without any coating and some also without any iron. Small quantities of iron are added to all clear glass frit and that gives the glass a slightly green tint when looking at the cut edge. This creates problems with high indoor temperatures caused by solar heat. In order to keep the solar heat out, solar shading devices are installed. When the sun shines, these cover the façade with fabric or metal devices that totally "kill" the transparent look of the building and prevent people from looking out.





Pictures 6 and 7: Ny Kredit, Copenhagen. Transparent and with solar shading.
Architects MAA Schmidt, Hammer & Lassen.

Which to you prefer: A totally transparent building all year round or a transparent building only during cloudy days?

7. AVOID MISSTAKES

It is possible today to find glass combinations that provide high daylight transmittance, noise reduction, good thermal comfort and energy savings. That requires, however, good glass knowledge as well as understanding of ventilation systems and building design.
It is also important to simulate in computer models the ventilation requirements, thermal comfort and energy balance of the building. CFD Prediction of Ventilation Flowfield Efficiency and IDA are some of the tools we use. We can predict detailed microclimate flowfield distributions that can readily assess "what if" issues.

It is astonishing to see how many glazed buildings have been completed on bases of old assessments and not on knowledge. The results are glass breakage because of thermal stress, discomfort caused by overheating, down drought, radiation etc.

When planning a glass project, it should be natural to include a glass expert in the project team, as it is to include an architect. Involving a glass expert at an early stage, will save production costs, time and save you from bad experiences.

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Erie-Ellington Homes: A New Paradigm Sustainable Urban Low Income Housing

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1.0 INTRODUCTION

The Erie-Ellington Homes project was a very exciting opportunity for the Hickory Consortium and the Building America Program to demonstrate the viability and advantages of "green" building for the affordable housing market. Too often, homes designed to exacting environmental standards and using innovative, environmentally sound materials and components are expensive to build and purchase. In the Erie-Ellington Homes, we have demonstrated that affordability and environmental responsibility are not mutually exclusive. In this report we'll discuss this sustainable urban low income housing, and present some of the approaches taken by Hickory in the Erie Ellington project. We provide an overview of the project and current performance. We will discuss the processes developed and lessons learned that will inform future work.

2.0 PROJECT OVERVIEW

The Erie-Ellington Homes development brought 50 beautiful, affordable homes and a community center to the Four Corners Neighborhood of Boston. In this inner city Boston project, Codman Square Neighborhood Development Corporation (CSNDC) developed five parcels on Erie and Ellington Streets in Dorchester, Massachusetts for affordable rental housing and a community building. The project was designed with sufficient scale to counter the blighting impact of the unusually large number of vacant lots (24%) in the neighborhood which are both scattered between housing and clustered into a number of sizable tracts. The five parcels in the project amount to 3.6 acres.

The units were built to EcoDynamic™ Homes specifications and produced as panelized housing. The EcoDynamic™ spec seeks to apply a systems approach to building combining ecological and economical performance.

Erie-Ellington homes were designed to

- use 49% less energy than standard homes;
- use 41% less water;
- reduce air pollutants by 25-60%;
- cost 25% less to build, and
- reduce annual water, electricity and heating operating expenses by 46%

3.0 PROJECT STATUS

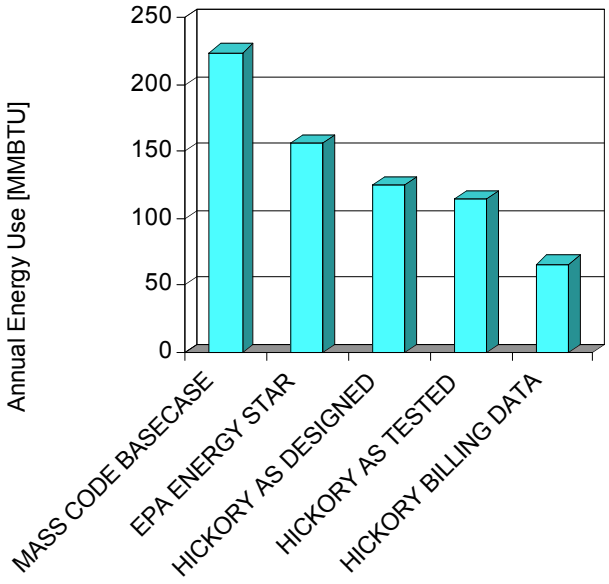
Construction completed in 2000 and the homes have been occupied for 1 to 1 ½ years. Construction costs were 25% less than typical construction costs for the Boston area. After 1 ½ years of operation, data from actual utility bills for the project were analyzed with dramatic results: total energy and water cost savings approached 50% compared to standard construction.

4.0 PROJECT PERFORMANCE

The key to the environmental performance of the design is whole building design. Hickory Consortium architects and engineers considered all of the components of a home, and how they interact to make design decisions. A whole building approach made it possible, for example, to use higher quality low-e windows. Good low-e windows cost a little more, but because they help conserve energy, engineers were able to design smaller equipment to heat each building. This saved the project money and energy.

Compared to a base case building conforming to the stringent Massachusetts building code, the performance of the typical Erie Ellington home used 42% less space heating energy, 27% less domestic hot water heating energy, and 59% less electricity. The dramatic increase in utility prices within the past five years makes these savings even more important to the owners. Within that period, gas prices increased by 45%, electric prices by 102%, and water prices by 38%. The fundamental energy savings were reflected in even greater dollar savings due to the price increases for utilities. On a dollar cost comparison basis, the data shows the owners paid: a 62% less for space heating, 42% less for domestic water heating, 75% less for electrical use, and 9% less for water consumption. Overall, the actual energy costs were better than the originally estimated costs when adjusted for price increases for utilities.

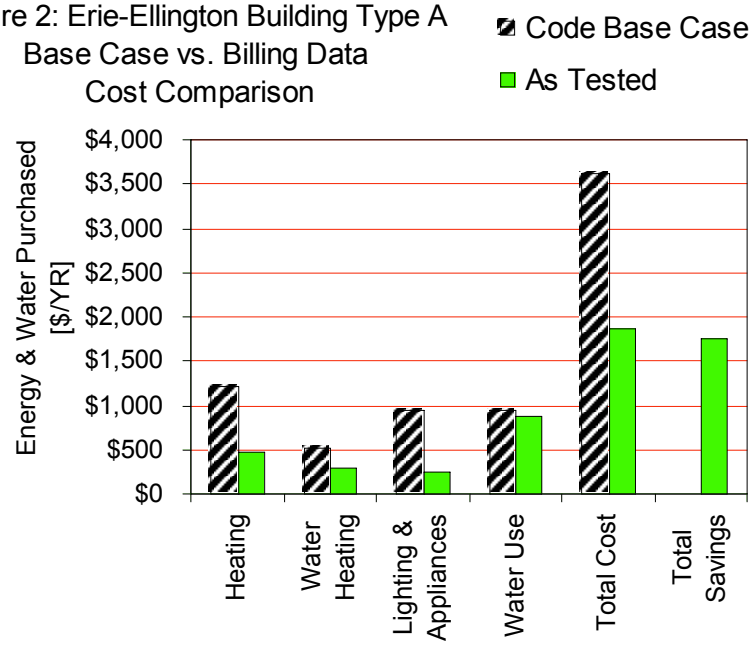
Figure 1: Energy Use Compared to Design Standards



Hickory's systems based approach helped to produce housing with both tighter construction and better ventilation. Healthy materials choices, like natural linoleum, certified carpet, and wood flooring also helped create a healthier indoor environment. Post construction tracer gas tests showed the ventilation system providing an ideal .35 air changes per hour – plenty of fresh air for occupant health and moisture removal. Interviews with new residents report good health results as well: symptoms were noticeably reduced in 8 out of 18 children with asthma problems.

Finally, a side by side comparison of the dollar costs of each resource shows a total savings for a triplex building of $2448, with a $750 contribution from decreased space heating demand, $216 from domestic hot water use reduction and efficiency, $714 from lighting and appliance conservation, and $74 from reduced water consumption. This results in an overall cost reduction today of 49%.

Figure 2: Erie-Ellington Building Type A
Base Case vs. Billing Data
Cost Comparison



3.0 EcoDynamic™ SPECIFICATION

The Erie Ellington project was built to the Hickory developed **EcoDynamic™ Home** specifications. These specifications are written to help developers, architects and builders create EcoDynamic™ Homes that are

Economical — cost less to build, maintain, and operate

Ecological — save energy, are built from high quality recycled and environmentally friendly materials, and promote health and comfort in a sustainable living environment.

Dynamic — incorporating ever-improving technologies and materials, adapting to ultiple needs: urban sites, economic constraints and complex programs

The **EcoDynamic™ Specification** seeks to maximize energy efficiency, health, comfort, durability and environmental benefits while minimizing cost. Through systems engineering,

careful design, efficient manufacture and construction, advanced technologies and materials can be incorporated in homes of high quality and low cost. Unlike most building specifications which only tinker with the parts after the design is complete, the EcoDynamic™ specification is considered part of the design process, influencing the configuration of building parts, the size of components, and the location of conditioned areas. The EcoDynamic™ Specification yields an ever changing mix of materials and designs, the overall specification reflects the goal of maximizing performance so construction will meet performance tests. The specification represents an integrated approach to design and construction of housing. It also incorporates a new approach to the construction process encompassing partnering and teamwork, scheduling and management, performance testing requirements, documentation and contracting language, and tangible measurements of success.

3.1 Whole Building Design

The Hickory Consortium **whole building approach** to energy savings begins with building envelope enhancement through design improvements, selecting the right areas to insulate and cost-effective improvements to the performance of components. We look at the amount of energy passing through each component, and evaluate the potential for reducing heat losses or cooling gains, the loss through air infiltration is reduced by tightening the building envelope and ducts. This is achieved with the help of instrumented weatherization testing, which helps identify sites of air leakage that are not visible, so they can be sealed. Because fresh air is a prime concern, mechanical ventilation is added, to assure occupants of good indoor air quality at all times. Once the envelope savings are achieved, appliance energy is reduced, first by reducing the demand by cutting hot water use, then adding efficient lighting and appliances. The distribution of heat is made more efficient by enclosing all pipes and ducts within the heated spaces, so no heat is inadvertently lost to the outdoors before it reaches the rooms. Finally, equipment is sized appropriately for the new, lower loads and the efficiency of the equipment is improved. The end result is an optimized building that uses far less energy and costs less than a standard house due to the reduction of equipment cost as well as reduced distribution system sizes.

3.2 Performance Testing

A key feature of the EcoDynamic™ Specification is the inclusion of **Performance Testing** — a number of performance targets are identified in the spec to be verified by field testing. Blower door, ventilation, and duct sealing tests are required to be performed to test the specifications for air tightness, ventilation rates, sound, and heating and cooling energy levels.

3.3 Partnering Process

Even more importantly, the specifications lays out a process, called **Partnering**, for coordinating, scheduling and communicating between parties on the job. The combined efforts of the owner, builder, component manufacturer, subcontractors, project manager, architect and engineers will be coordinated through this process. All parties begin the job with a partnering conference, where agreement will be reached on issues of communication, documentation, schedule, reporting etc. This process leads to an unambiguous, smoother, and less costly project. The **contract structure** must be established to ensure successful implementation of the specified improvements, and will document the agreements reached between all parties at the partnering conference. The architect will clearly document and explain expectations, and the payment schedule includes payments based upon the performance testing to encourage attainment of goals.

The Partnership model calls for all participants – owner, architect, engineers, contractor, sub-contractors, and workers -- to agree upon well-defined goals and act in a coordinated, cooperative fashion, instead of in an adversarial manner. For example, in the Erie-Ellington project, one of the critical goals is energy efficiency – a performance goal that affects all of the players because of the care needed in the construction phase to tightly seal the buildings. The owners, Codman Square Neighborhood Development Corporation/Erie-Ellington Homes, Ltd., were amenable to using the Partnership model. They hired as the on site owners' representative, construction consultant Jennifer Pinck, who also joined the Hickory Consortium. Pinck, architect Bruce Hampton, and energy engineer, Mark Kelley worked with the owners to insure that the specifications for the project were exact and complete as to the steps required to meet the project goals. In addition, the specifications called for frequent and detailed progress reports so that the critical goals of on time, within budget construction could be met. The specifications were bid and a pre-bid meeting was held that explained the goals of the project and the main features of the specifications. During construction, several meetings were held with the players to ensure that project goals were understood. In addition, the architect, owners representative and contractor met weekly to review progress.

3.4 Measurements of Success

Hickory has developed an ambitious series of environmental and energy goals as a vision of what housing can be, and has set up a benchmark system to quantify progress toward these goals and establish **measurements of success** for a project.

The ranking system scores the building in relation to a base case building of typical site-built construction that meets the CABO Model Energy Code. This chart graphically compares an Eco-EcoDynamic™ Spec building to a similar building built to typical housing standards. The circle around the outside is typical of "Best Current Practice". As impacts are reduced, the overall circle moves in towards the bullseye, with a zero impact dwelling in all areas being a dot in the middle. These goals are embodied in the EcoDynamic™ Home Specification.

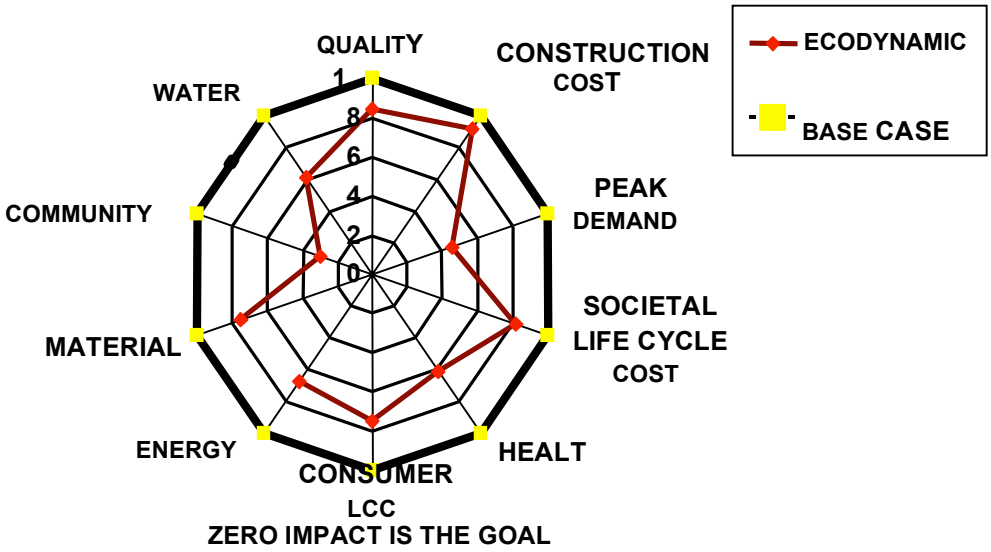


Figure 3: Bullseye

4.0 CONCLUSION

Designing and building low income housing presents the problem of sustainable design in terms that starkly demand clarity of goals. Because of the imperative of low cost, there is no room for greenbuilding frills, yet it is possible to attain a high level of environmental performance without sacrificing cost. While most sustainable building projects embrace a wide variety of desirable goals, low income housing requires strict prioritization. Our effort in Erie-Ellington Homes was to look to the environment for guidance in selecting sustainable features. We found that we could, by adhering to environmentally rational priorities, capture the lion's share of the potential environmental benefits, while still keeping costs well below standard construction.

The Erie- Ellington success would not have been possible without the willing and able partnership of construction crews and project managers. CWV Builders' construction superintendents, with City and Codman Square Neighborhood Development Committee (CSNDC) managers, worked in partnership with our designers to realize construction specifications – on time and within budget. The result of their dedication to quality and better performance – and willingness to do things a little differently – is an outstanding low income project that performs better than most market rate housing. Erie Ellington Homes are a model for how environmental friendliness and affordability can be brought together in beautiful new homes for our community.

Hickory Consortium, a member of the U.S. DOE Building America Program, has designed, planned, specified and partnered a breakthrough sustainable low income housing project. Though there is always more to be done in the area of sustainability, we are most encouraged by the results of this project.

Double-wall with integrated functions resulting in an energy-saving building

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1. INTRODUCTION

Soerveggen AS (SV) has developed a new building façade concept based on a double-wall construction with integrated functions and mechanisms resulting in lower total energy consumption. The product is designed for optimal utilisation of the microclimate and solar energy. The double wall is faced towards the South (most exposed for solar energy in the Northern hemisphere).

The product is patented in Norway. An international PCT[1] patent procedure is in progress, and will be concluded later this year.

A contract is entered with Vest-Agder fylkeskommune (VAF) for a 3-floor clinic, a new building of 1.800 m^2 area located in Kristiansand. Design start is scheduled June 2002 with construction to begin in late November the same year. VAF is a county administration, and is a professional owner and estate manager of schools, office buildings and hospitals. Political decisions on a sustainable building strategy is taken, and energy-use strategy for future projects will be based on the success of this building.

2. ENERGY – INTEGRATED SOLUTIONS

The main motivation to install SV is the energy saving potential. According to study results this potential is between 30-50%. Solar and wind energy are utilised to produce drive forces for natural ventilation. Solar collector plates supply energy to radiant floor heating systems and domestic hot water. Daylight collectors are integrated in the double wall. The sun shading system works automatically to optimise the ratio of shade to daylight.

3. INDOOR CLIMATE

The indoor climate is equal to or improved compared with conventional systems, due to the quality of the low-flow, pre-heated or pre-cooled ventilation air, low noise level, daylight levels, and the combination of user-controlled and automatic operation of the systems.

4. DESIGN BRIEFING

4.1 Architectural respects

As a façade design influence on the architectural overall concept, the double wall must to be adaptable and flexible to the use of materials and design principals. The wall will, however, necessarily have a modernistic impression due to the use of glazing and aluminium support structure. In addition, several installations in between the glazing will give an exciting impression of lines and movements (regulation of vertical shading lamellas) during the day.

[1] PCT (Patent Cooperation Treaty)

Different types of glazing may be used to break up the façade, together with pillars and different materials in façade elements. Architects have been involved during the study phase to clarify the system's architectural potential.

4.2 Support structure
Extruded aluminium profiles are used for the support structure. The wall is self-supporting and mounted onto a horizontal concrete foundation, which also includes a ventilation culvert (air duct). Transportable modules are prefabricated in the workshop and then assembled at the construction site, interfaced to the building structure and related systems.

Extruded profiles are suitable for multifunction requirements related to assembly, tightening, installation of glazing and equipment. Each module height is equal to the distance between floors.

4.3 Ventilation
The ventilation system is a natural or hybrid system with inlet air flow passing through a conduit below ground at a stable temperature level (through all seasons and times of day). Consequently the inlet air is pre-heated during wintertime and pre-cooled during the summer.

Further, the air flows vertically through the inlet sections of the double-façade, and is distributed via horizontal channels, integrated in prefabricated floor elements, if relevant, to each building section, area or room. Air is evacuated through vertical outlet sections of the double façade at the roof level of the building.

The air flow channel capacity required is estimated to be approximately 20 % of the total capacity of the wall, assuming a flow rate of 2 m/s and a requirement of 6 m^3/h per m^2 of building area.

4.4 Heating
Water should be used as an energy exchange and distribution medium, integrated with the solar collector panel system. The panels are placed inside the outer glazing of the double wall, and insulated from heat exchange to the wall. Such water-based heating systems may be built as a floor circulation system or alternatively, wall mounted radiators may be used.

Assume that collected energy at the double-façade is approximately 500 W/m^2. Depending on building geometry, this results in 20-40% energy savings related to heating, including production of domestic hot water.

4.5 Cooling
The product also has potential for cooling. In Norway air-conditioning of buildings should not normally be specified due to the outdoor temperature level, installation costs and energy consumption. A cooling effect of lower temperature of inlet air is also utilised. Also the water circulation system (described under heating) may be utilised for heat exchange between warmer and colder areas of the building. The building body may also be cooled during the night by ventilation. Alternative solutions are also discussed in the product design reports.

4.6 Sun shading
Sun shading is arranged by use of vertical lamellas inside the double-wall. Vertical shading is assumed to be more efficient than horizontal in Nordic countries due to the low sun angle during most of the year. By minor adjustments of the lamella angle around a central axis, sufficient shading is obtained. The adjustment is controlled automatically according to sun

movements. During the night the lamellas can be 100% closed, thereby functioning as insulation.

The lamellas are produced of thin-wall aluminium profiles, and may be coloured to improve the architectural impression. Also the lamellas may be integrated to the solar collector system if equipped with a heat exchanger inside the body. In this situation most of the wall is an active solar energy collector.

4.7 Lighting

To reduce as much as possible the energy used for electric lighting, a daylight collector system is integrated in the upper section of wall. Reflectors distribute natural lighting further into the building core. The daylight system is fully integrated with electric lights that function automatically when required.

In addition to the energy saving potential, which may be as much as 25% of total, some studies have shown that daylight has a positive mental effect compared to electrical lighting.

4.8 Glazing

Modern glazing is available in variants with technical qualities that have optimal effects on energy utilisation and comfort qualities. The façade, inner, and outer glazing in the double wall will make the best use of these different qualities.

Specification of glass qualities also impact fire and noise resistance. As an alternative to glazing, photovoltaic panels may be useful in adequate quantities. This is, however, not normally specified as part of the SV product, but is still relevant.

According to studies, the outer glazing should have lower U-value and higher heat-reflection ratio than the inner, to reduce the temperature in the double-wall zone. This may seems to be a conflict, as ideally as much energy as possible should be collected. The crucial problem is accumulation of energy, and distribution to the occupants when needed.

4.9 Solar energy collectors

Standard, well proven solar energy collectors are specified. The normal, and more efficient panel location is at the roof, angled toward the sun. In our case the huge effective wall area compensates for a more reduced area normally feasible for the roof system. In Nordic countries this loss of effect is minimal during wintertime, spring and autumn.

4.10 Control systems

An important quality of the SV system is that the wall mechanism is adapted to the microclimate, especially temperature, humidity, wind, daylight, and solar energy, at any time. The SV has to be continuously regulated.

- Ventilation system is opened / shut as required.
- Sun shading lamellas are regulated according to sun “movements”.
- Water circulation valves regulate flow according to heating or cooling requirements.
- Daylight system is regulated to an optimal effect.

Two dominating requirements are that the solar energy shall be utilised as much as possible, and that the indoor environmental quality be maximised. Therefore the control system also considers parameters related to the building geometry, heat transportation, and energy accumulation. The SV wall is harmonised with the entire building body and functions.

The central control system is a modern computerised system securing necessary data collection, processing of data and regulation of functions.

4.11 Noise

Noise problems may occur related to ventilation through open windows, when controlled by the user. This possibility is important for the satisfaction of the user. Window ventilation is possible by a channel through the double-wall. The channel is narrow and high, from floor to ceiling, and is very effective. Fresh air intake will be predominantly near the floor, and evacuated near the ceiling.

Such ventilation will be influenced by traffic noise, and acceptable ventilation time must to be regulated according to legal requirements. We do not see this noise as a relevant problem area.

Noise transmissions between floor levels vertically and between rooms horizontally are, however, potential problems. The most important actions seem to be related to the design of the inner side of double-wall interfacing the building body. Connections between inner side of double-wall and internal walls between rooms are also important due to flank transmissions.

4.12 Fire protection

Fire protection of the double-wall is a similar challenge as for other building elements with open vertical channels. The inner-side design of double-wall construction is, as discussed under noise, very critical.

5. COST – ENVIRONMENTAL BENEFITS

5.1 Investment costs

Calculation of investment costs is complex if the intention is comparison between the costs of the SV system including all functions, and the conventional alternative. This calculation involves the total of ventilation system, heating system, façade system etc.

Current estimates show that the total investment of SV is even lower than the total of conventional systems.

5.2 Life cycle cost

The life cycle costs estimate considers all costs accumulated during a lifetime of 50 years, including investment costs, cleaning, maintenance and repair costs, energy consumption etc.

Current estimates shows that the LCC costs of SV are very comparable with a conventional system. The reason is basically related to the saving of energy.

5.3 Other aspects

Introduction of the SV double-wall concept will be most successful if the concept is considered as an integrated part of construction, as early as possible in the planning process. So-called partnering organisation of the project will be much preferred, as all technical disciplines and the entrepreneurs are involved from day one.

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The Environmental Effects of an Improved Thermal Envelope Adaptations to Future Regulations

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INTRODUCTION

Noticeable changes in the ecological system and increased knowledge of the impact of human activities have resulted in a growing interest and concern for the environment in the last decades. Important consequences of the increased knowledge in the environmental field and the need for improvements are the political decisions to reach environmental agreements and universal goals. Important international examples are the Rio Declaration (United Nations, 1992) and the Kyoto protocol. In Sweden these international documents are a major reason for the development of a national environmental strategy and the decision of the parliament to endorse fifteen environmental quality objectives (Swedish Parliament, 1999).

A major sector to address in order to minimize the industrialized society's impact of the environment is the building stock and the building industry. This sector is responsible for almost 40% of the total energy use in Sweden (STEM, 2001). Due to the general environmental impact from the energy production they are key targets in order to implement ecological sustainability.

During a period from the mid 1965 to 1974 more then one million dwellings were produced in Sweden, two thirds being flats in multi family buildings (Hall et al, 1999). Almost 30 % of the Swedish dwellings that exist today were erected during that era (SCB, 1997). Buildings from this period were not constructed according to today's regulations and standards and are not as energy efficient as modern buildings. Due to the fact that the yearly production rate of new buildings is now only a tenth compared to the peak years in the late 1960´s the renewal of the building stock is a slow process. In late 2001 the council of the European Union and the European Parliament presented a proposal for a directive on energy performance of buildings (Council of the European Union, 2001). The target of the proposal is to make the energy use in buildings more efficient and to reduce the environmental impact.

Objectives

The intention of this study is to investigate possible technical alterations and their impact on an existing multi family building in order to reduce the environmental impact during the remaining part of the life cycle, by applying the proposed directive to the European Parliament. Other studies of new multi-family buildings (Adalberth K et al, 2000) has proved that the occupation phase is the part of the life cycle with the highest energy demand and the largest impact on the environment. This indicates that by upgrading existing buildings their environmental performance can be increased. The results of the alterations are presented as changes in environmental impacts using LCA methodology.

Limitations

In order to reduce the energy use and its contribution to the environmental impact of a building there are several possible methods. One choice is to improve the overall thermal

performance of the building envelope and thus reducing the amount of energy for heating. Another possibility is to reduce the energy demand by changing to more effective building services such as ventilation and heating. A third alternative is to conserve energy by actually reducing the performance of the building or its system. This can include lower exchange rates of the ventilation systems or a reduced indoor air temperature. This study focuses on methods for improving the building envelope and thus reducing the energy needed for heating. Improved thermal insulation of external walls and roof are evaluated as well as a change to low energy windows. Alterations to other parts of the envelope, installations and services or reduced indoor air temperatures are not included in this study. The data on energy use in this study was obtained from calculations and not actual measured numbers. This makes comparisons more accurate, since the energy use in the original building as well as the energy use after changes in the thermal envelope are obtained in the same way.

Other studies

There are other studies performed regarding reducing the environmental impact by improving the thermal insulation. One study, (Erlandsson et al, 1997) accessed the environmental consequences from different thickness of external mineral wool insulation on a multifamily building erected during the 1930s. The results show that pollutant emissions could be reduced during the life.

THE BUILDING

The building analyzed in this study is one of thirteen just about identical buildings in the municipality of Burlöv, situated outside Malmö in southern Sweden. It was erected in 1970 and is a typical multi-family building from that period in Sweden. The external walls were constructed as a 120 mm half brick wall with air gap, 3 mm internit, 100 mm mineral wool, polyethylene foil, 13 mm gypsum board, with a total thermal transmittance U = 0.31 W/(m²·K). The gable walls were constructed as a 120 mm half brick wall, 100 mm mineral wool and 150 mm concrete, with a total thermal transmittance U = 0.30 W/(m²·K). Table 1 includes the other major characteristics of the building system and the thermal performance of the building envelope. The attic floor was constructed from 160 mm concrete, 100mm mineral wool and 50 mm concrete on top. The total thermal transmittance of the roof is U = 0.31 W/(m²·K). The bottom floor was made out of 70 mm wood wool with approximately 160 mm concrete and carpet on top above a cellar.

Table 1. Basic characteristics of the Burlöv building

Parameter	Value
Number of apartments	70
Number of floors	8
Total usable floor area	4900 m²
Framework material	Concrete
Ventilation system	Mechanical exhaust air
Heat source	District heating
Space heating system	Radiatiors
Total façade, excluding windows	2332 m^2
Total window area	790 m^2
Attic floor/ Bottom floor	752 m^2

The energy use in the Burlöv building was estimated using the Swedish ENORM 1000 software. The results are presented in Table 2.

Table 2. Estimation of the energy use of the Burlöv building

Energy source	Energy use (kWh)	Energy use, per area (kWh/m²)
District heating & domestic hot water	553 500	113
Electricity	281 200	57
Total	834 700	170

METHOD

European Directive on Energy Performance

According to the proposal for a directive on energy performance of buildings to the council of the European Union and the European Parliament the energy performance of a building is to be expressed in a transparent manner and may include a CO_2 emission indicator. One of the requirements for establishing an improved energy management of the buildings within the union is to set minimum requirements on the energy performance of existing buildings subject to renovation. In article 5 of the proposal it is stated that buildings with a useful floor area greater than 1000m^2 that are the subject of major renovations are to have the energy performance upgraded in order to meet minimum requirements as far it is technical, functional and economical possible. Major renovations is defined as investments in the building envelope or installations that exceed 25% of the value of the building or when more then 25% of the envelope is renovated. The degree of upgrading required is to be set on a national or regional level and *may* differ between new and already existing buildings (Council of the European Union, 2001).

The proposed directive for the European Union implies the member states should incorporate its framework with the Member State legislation. In the case when a specified standard for existing buildings does not exist, it is possible to set the energy performance requirements for renovated existing buildings on the equivalent level of the national regulation for new building. Since there is no building code to fulfill for already existing buildings in Sweden the proposed regulations of alterations in the building in this study are interpreted as compliance of the existing Swedish building code for new buildings, BBR. This can be viewed upon as a rigid but not impossible interpretation. In order to fulfill the requirements of the BBR code the Burlöv building originally outlined in Table 1 has to reach a maximum average thermal transmittance $U_{m,krav}$ = 0.347 W/m²·K (Boverket, 1998). In this example it would be approximately the equivalent of a total energy use of 81 kWh/m^2*year for district heating and domestic hot water.

The environmental impact

In this study four different environmental effect categories were studied: global warming potential, acidification, photochemical ozone creation potential and eutrophication. The life cycle studied includes manufacture of materials, material transports and occupation of the building. The emissions from the occupation in defined as those from the total energy use in the building, i.e. from domestic hot water, district heating and electricity. Since the total content of building materials in the Burlöv building is not known, also the final demolition of the building was not included.

RESULTS AND DISCUSSION

In order to reduce the thermal losses through the building envelope and reduce the energy demand for district heating three types of alterations were studied, individually and in combinations. The external facade were added additional insulation using a system with mineral wool with an outside rendering tied to the brick façade. The maximum thickness of the mineral wool insulation tested was150 mm. Also extra thermal insulation of mineral wool

of maximum 300 mm on the attic floor was examined. These values for the façade and attic insulations were chosen as the maximum possible from a technical point of view.

Changing of the windows was also studied, exchanging existing two pane windows (U-value of 3.0 W/m²·K) with modern low energy windows (U-value of 1.1 W/m²·K). In Table 3 the changes are compared to the actual building and the resulting energy use is listed. Since no changes were simulated in order to reduce the use of electricity this parameter was not subject to changes. Thus it remained 57 kWh/m^2*year as in the original case, Table 2. The indoor air temperature was set to 22 °C based on an average from study of 1100 Swedish houses (Norlén et al, 1993). In Table 3 the studied cases of changes in the thermal envelope are outlined. The right column indicates the nature of each case, F for changes in the façade, A for attic and W for window. BBR1 and BBR2 are two cases were the average thermal transmittance is equal to the BBR regulation, while (F+A+W) is the maximum potential of reducing the energy use for district heating and domestic hot water.

Table 3 Alterations to the Burlöv building and the resulting district heat energy demand.

Insulation fasade mm	U-façade W/m²·K	Insulation attic mm	U-attic W/m²·K.	U-window W/m²·K.	T_{indoor} °C	$U_{average}$ W/m²·K	Heating kWh/ m^2·yr	Case
-	0.310	-	0.310	3.0	22.0	0.738	113	Original
150	0.134	-	0.310	3.0	22.0	0.640	105	F
-	0.310	300	0.092	3.0	22.0	0.699	110	A
-	0.310	-	0.310	1.1	22.0	0.380	83	W
150	0.134	300	0.092	3.0	22.0	0.601	101	F+A
-	0.310	200	0.120	1.1	22.0	0.346	81	BBR1
50	0.213	-	0.310	1.1	22.0	0.326	79	BBR2
150	0.134	300	0.092	1.1	22.0	0.243	73	F+A+W

Changing the windows is by far the most potential parameter for reducing the thermal energy use. The results show that the BBR standard only can be reached when either an increased façade or attic insulation is combined with exchanging the windows.

In order to make a LCA of the studied alteration the life cycle was set to 50 years. This is a realistic assumption from a technical and economic viewpoint. In order to assess the environmental impact energy, transport and material references were used from, (Tillman A-M et al, 1991), (Andersson et al, 1991), (STO 2000), (Swedish District Heating Association. 1999), (Erlandsson, 1997) and (Petersen E H. 1997). The energy used in during occupation was assumed to be a Swedish standard electricity mix and Swedish district heating. The building materials used were mainly produced in Sweden, Denmark and Germany.

In Figure 1a-d the result of the LCA study is outlined. In general the case the total maximum potential in changes in façade, attic insulation and windows (W+F+A) results in the lowest environmental impact. An almost similar result is reached from fulfilling the BBR regulations for new buildings. Only changing the windows does not satisfy the regulations but still results in roughly as low environmental impact as the most advanced case (W+F+A).

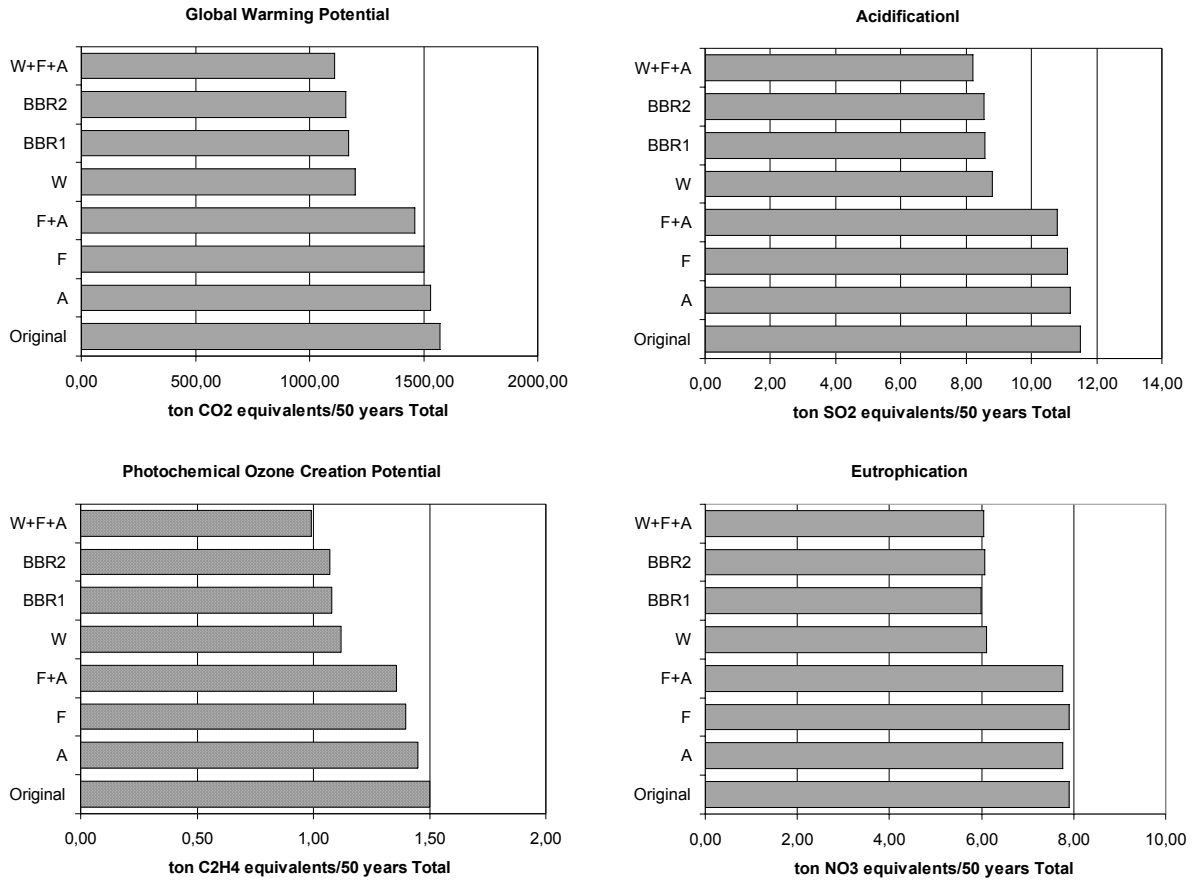

Figure 1a-d. The environmental impact in four different effect categories during a remaining life cycle of 50 years.

CONCLUSIONS

This study shows that a reduced environmental impact can be reached by applying possible future European Union Regulation. By using the existing Swedish regulation for new buildings on existing ones, this case demonstrate the possibility of a general 25 % reduction of the impact in four major effect categories. These reductions are obtained by using existing techniques, methods and building systems. The study shows that is possible to alter already existing buildings and reach a reduced environmental impact.

The results were obtained using Swedish energy mixes for district heating and electricity. If international energy date were used instead the result could be somewhat different. Since the energy production in Sweden compared to other most European countries has a lower impact on the environment using LCA, the potential for improvements such as addressed in this study could even be greater in other parts of the European Union.

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Long-term leaching of environmentally hazardous substances in admixtures, emitted from concrete

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1. INTRODUCTION

Studies on the environmental effects of building materials often focus on manufacturing and destruction processes, with emphasis on energy use and depletion of resources. This study discusses potentially hazardous substances in concrete and the diffuse emission of these substances to surrounding environments during use. Concrete is one of the most widely used construction materials. The use of admixtures in concrete is steadily increasing and as much as 700,000 tons of admixtures were according to Mäder (2000) used in Western Europe in 1999. The growing interest in environmental issues in the building sector has drawn attention to these admixtures, particularly concerning the risk of environmentally hazardous substances released.

Several studies e.g. by Hillier et al (1999) and Andersson (1999) have been carried out on the topic of leaching from concrete, above all on the leaching of heavy metals originating from concrete additives such as fly ash and blast furnace slag. Studies on the release of organic substances have to a great extent focused on water-reducing superplasticizers, which represent the largest volumes used, see Pollet et al (1997). However, the concentration of hazardous substances in superplasticizers are usually very low.

In this study the focus is on elements with proven ecotoxicological effects, present in commonly used concrete admixtures. The studied substances are sodium thiocyanate, resin acids (in tall oil) and nonylphenol ethoxylate. The chronic toxicity to fish and humans, and the genotoxic effects of nonylphenol and resin acids of these elements are well documented but reviewed elsewhere (Lanno et al (1996); Mörck et al (2000); Burggraaf et al (1996); Pacheco et al (1999); Lye et al (1999)

The admixtures concerned improve the concrete in different ways. Thiocyanate accelerates the hydration and increases the strength. Air-entraining admixtures provide an even distribution of air bubbles in hardened concrete, and thereby frost resistance. Natural polymers, such as tall oils, are besides tensides like nonylphenol ethoxylate the main products used. Resin acids in tall oil are diterpenoid carboxylic acids present in most softwood species; dehydroabietic acid and abietic acid being the most abundant, according to Back et al (2000).

In an earlier study, Andersson et al (2001), the diffusion based leaching of thiocyanate and resin acids in concrete admixtures were studied. The time-dependent release were measured during 30 days showing that a diffusion steered leaching is present, and that 6-8% of the studied elements were released from 4*4*16 cm pieces of concrete in water that was changed four times. But still there is a lack of information on the long-term leaching, and about the

amount available for leaching, i.e. the amount that is not firmly bound to the cement matrix. The main focus in this report is therefore on the amount of elements that can be leached in a long-term perspective.

2. LEACHING TESTS

2.1 Materials and methods

Materials and admixtures used for the concrete test specimens are presented in Table 1. The abbreviation used for each admixture is later used for the results of the concrete specimens. One accelerating admixture (A) with thiocyanate and two air-entraining products AEA1 and AEA2 were used. The thiocyanate containing concrete (A) and one of the AEA's (AEA 1A) was made at an earlier occasion, and has been stored 3 years in a climate chamber with 20 °C and 85 % relative humidity. This type of concrete was first cured in moulds for one week and then stored in 85% for 20 weeks. The other, newer type was cured in the moulds for 24 hours, then water cured in 25 ° and 100% relative humidity for another 24 hours, and finally water cured in 20 °C for another 72 hours. After two weeks storage at 20 ° C and 50 % RH the specimens were crushed into a size < 2 mm and a size of < 10 mm. This applies to all concretes but four 4*4*16 cm specimens of concrete A, which have been studied in an ongoing diffusion test since 990113 and will also be reported here.

Table 1 Materials and admixtures used for the concrete specimens.

Cement:	Swedish Portland cement (PC1) complying with ENV 197 (Skövde)
Aggregates:	Crushed rock in 8-12 mm, gravel in 0-8 mm, sand in 0.068 - 0.354 mm and 0.125 - 0.707 mm, fine quartz sand (as filler)
Added was one of following three admixtures:	
1,25% of cement content:	Accelerator (A), containing 7% sodium thiocyanate (CAS 540-72-7)
0,4% of cement content:	Air-entraining agent (AEA1), containing 5% tall oil resin (CAS 8050-09-7)
0,2% of cement content:	Air-entraining agent (AEA2), containing 18% tall oil (CAS 8002 26-4), 5-10% alkyl ethoxylate sulphate (CAS 68585-34-2) and 0,2 % nonylphenol ethoxylate (CAS 9016-45-9)

The existing standard leaching test for concrete, NEN 7341, is an availability test that aims at determining the fraction that is available for leaching, by stirring finely ground (<125 μm) concrete specimens in demineralised water at pH=7 for three hours, and at pH=4 for another three hours. The test gives information about the long-term leaching — but not the time-dependency. In that extremely aggressive environment very little of the function of the material is left. The ambition here has been to test the concrete during conditions which are aggressive, i.e. small size of the concrete particles, a high liquid/solid ratio and a duration of 24 hours, but with no added acid and a much larger size of the grounded particles than in the standard. The test is still very much an acceleration of the leaching in reality for concrete that

is still functioning as a construction material. For concrete as a filler material in road banks etc the test is more realistic. We used 30 mg of material to 1 litre of nano-pure water, covered the beaker and let the water circulate rather slowly, without moving the concrete around. After 24 hours the water was filtered and analysed.

The diffusion test with concrete type A that has been ongoing since 990113 has been part of a larger diffusion leaching test with concretes containing tall oil (AEA 1A), thiocyanate (A) or different types of slag and fly ashes (containing heavy metals). The test is to a great extent completed and has been reported earlier, see Andersson (1999), Andersson et al (2001), but the thiocyanate test was proceeded to see what will happen at a longer perspective. When the test started in 1999, the concrete specimens were placed in containers filled with nano-pure water so that all sides were covered. The liquid/solid ratio was 5 [m^3/m^3] and the leached water was renewed and analysed four times during 30 days. The thiocyanate containing concrete was then left for over three years until now when the final analysis of the water was made.

3 RESULTS AND DISCUSSION

3.1 Availibility test

The availability test showed quite a few interesting results, displayed in Figure 1 and Figure 2. One of the admixtures, AEA 1, has been bought at two occasions (1A and 1B). It seems as the content of the product has been changed rather much, if comparing the results from the old product, AEA 1A and the new product AEA 1B in Figure 1. The old concrete showed a much higher leaching than the newer, both in absolute figures and if compared to the amount that was added from the start. The leached amount is remarkably low for the newly bought product, which can imply that the content of resin acids in this product is lower, giving a too low estimation of the percentage of the original content that is leached. Further, almost only one acid was detected – the toxic dehydroabietic acid. Also compared to the earlier diffusion tests, where 6-8 % were leached during a month in a much slower leaching test, the figure of 2-3% leaching must be regarded as uncertain. However, the absolute value of the leaching is definitively lower than for AEA 1A.

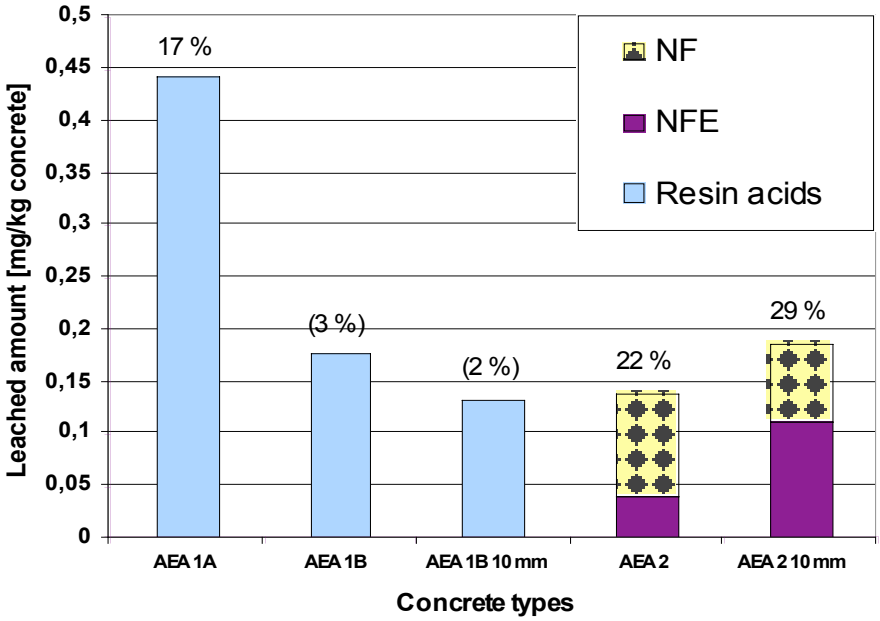

Figure 1 Leached amount of resin acids, NF and NFE in 24 hours availability test.

The other air-entraining agent, AEA 2, was only tested for its content of nonylphenol ethoxylate (NFE), even though it also contains 18 % of tall oil. The whole water volume was needed for the NF-ethoxylate analysis and its is very likely that this tall oil product would behave similarly to AEA 1. The result shows that 22 % of the NF- elements in the small-sized concrete and 29 % of the NF –elements in the concrete with particles < 10 mm were leached. More surprising is the detection of nonylphenol in the water. The product is said to contain a small dosage of NF-ethoxylate, but the results show a big fraction of nonylphenol as well. Nonylphenol is a very toxic substance and also very stable in the nature. One possible explanation is that the nonylphenol ethoxylate has been transformed to nonylphenol, an ordinary process in nature but still surprising here, as the time between concrete casting, leaching process and chemical analysis was very fast. Interesting is also the fact that as much – in fact even more – is leached from the concrete with large particles. Moreover, the relation between the nonylphenol ethoxylate and the nonylphenol is very different, with a higher content of NFE in the concrete with large particles. It seems as it has been easier to degrade the NFE in the concrete with small particles. The phenomena can not easily be explain by uncertainties in the chemical analysis, which had very good accuracy.

The availability was also tested for concrete with thiocyanate. In earlier tests we have received very high leaching levels, and wanted to see if this was repeated yet again. In Figure 2 the fraction of the added amount that was detected in the water is displayed, showing that the percentage of leached thiocyanate is very high: 71 % of the added amount. In addition, the leaching of thiocyanate is also very high in absolute figures: 141,6 mg/ kg concrete.

Thiocyanate seems to be very easily soluble in water, which can be the reason behind this behaviour. It is also very clear that thiocyanate is not firmly bound to the cement matrix.

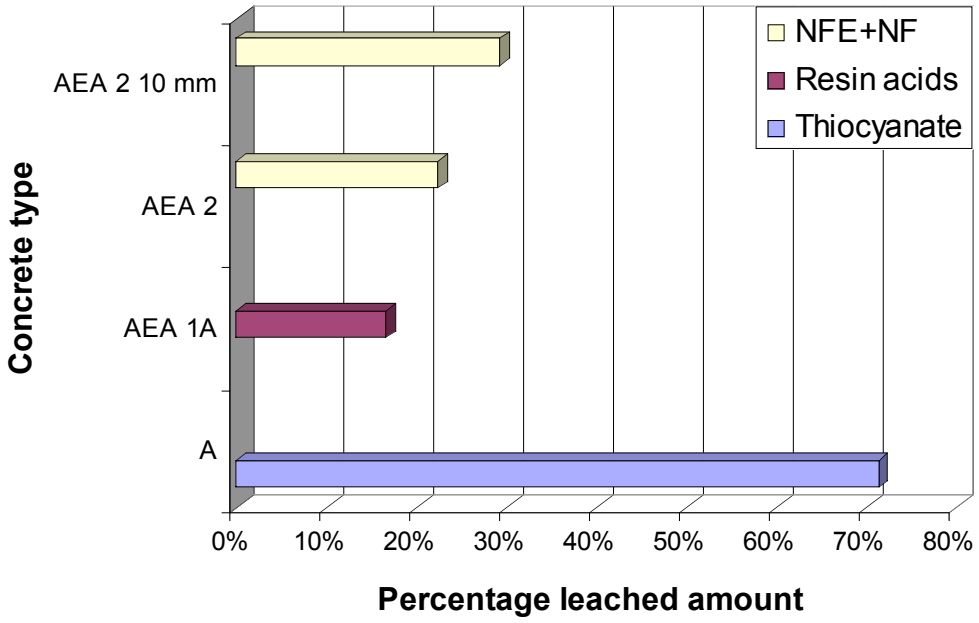

Figure 2 Percentage of originally added substance that is leached in the availability test.

Diffusion test

Also the leaching pattern for the diffusion tests that have been carried out earlier, shows a different leaching behaviour between the thiocyanate and the resin acids. Where the resin acids shows a continuous diffusion curve from the start to the last water renewals, the thiocyanate is emitted very fast in the beginning and very slowly already after 30 days, see Andersson (2001). To see whether the thiocyanate is still leached, but with a slower rate, the test was prolonged for over three years. The result is viewed in Figure 3, where the new figures are added to the old leaching pattern. The chart clearly shows that the diffusion of thiocyanate goes from a very high rate in the beginning, to a slow but still ongoing release after the third water renewal, which was after 15 days. This particular leaching pattern is intensified by the fact that all four specimens show exactly the same curve.

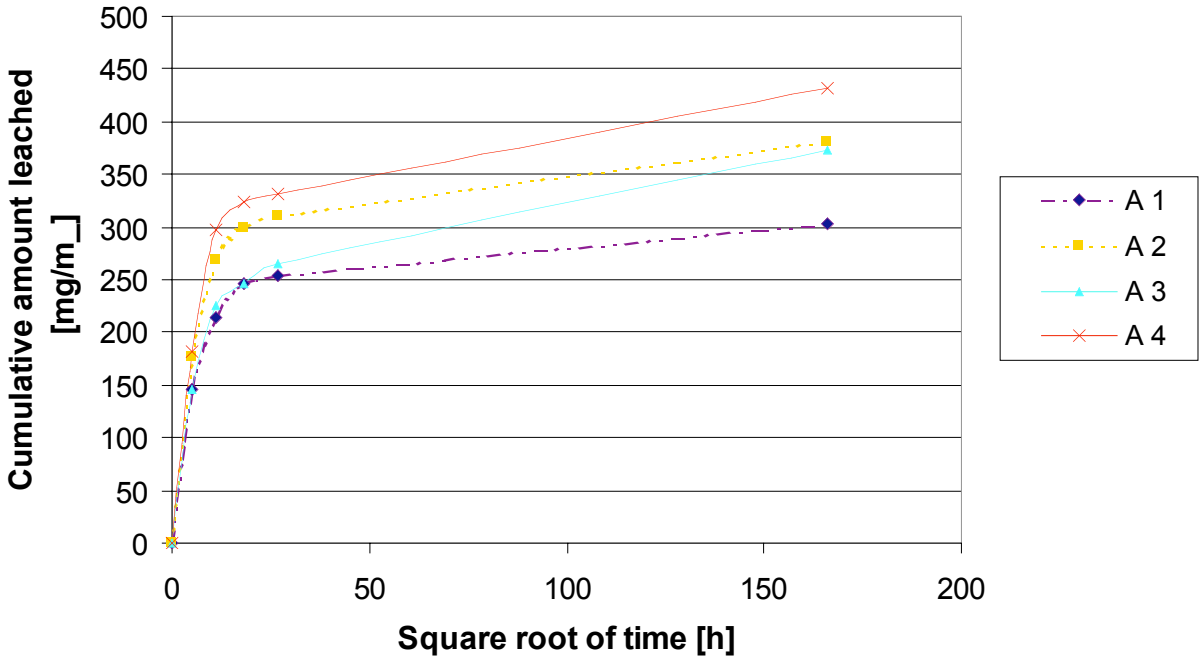

Figure 3 Cumulative leaching of thiocyanate from concrete specimens with accelerator A added. A1-A4 represent each specimen. Diffusion test with L/S ratio=5, renewed 5 times during 1146 days; after 1 day, 5 days, 14 days , 30 days and finally 1146 days.

CONCLUSIONS

From the laboratory results presented here, some main conclusions can be made:

- The long-term leaching behavior for elements in concrete admixtures is not uniform, but vary with the solubility of the element, and with the way the element is bound to the cement matrix.

- The long-term leaching for nonylphenol elements is ~20-30% of the added amount. The concrete emits not only nonylphenol ethoxylate but also nonylphenol – a more toxic, genotoxic and low-degradable substance.

- The long term leaching varied for the resin acids, which may be caused by an alteration of the tall oil mix used, to a lower content of resin acids. This possible modification of the product is very positive from an environmental point of view.

- The leached amount of thiocyanate in the availability test was very high, both in concentration and in percentage of added product.

The main reflections that can be made from the results of this study, is that hazardous substances in concrete admixtures can be released, slowly when functioning as a construction material, but faster when being crushed and reused in road banks etc. The results show the necessity of knowing what is being added to concrete, as the market for reuse of materials is growing and will continue to grow, with regard to other important environmental aspects.

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Harmful Compounds in Paint leached from Wooden Facades

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1. INTRODUCTION

One of the purposes with paint is to protect the material underneath, a purpose that is very important for wooden façades in a humid climate. A crucial task is to hamper microbiological growth, and this is most often done by means of a small content of biocides in the paint. Biocides are often harmful to the surrounding environment, and it is important to see whether these harmful substances stay in the paint film or if they are released when exposed to rain.

The aim of this project has been to see if harmful substances in façade paint can be leached to the surrounding environment. Research in this field is very scarce, and has concentrated mainly on anti-fouling paints in marine environments (Rascio, 2000). However, Davis and Burns (1998) made a study on leaching of lead from painted structures, giving clear indications on the important contributions from these sources to lead pollution in soil. It is therefore of great interest to further investigate this question, and to see whether other compounds with a toxic character in paints are released, such as biocides in water-borne paints.

2. MATERIALS AND METHODS

Wooden panels were painted with three types pf paint systems including appropriate priming paint. The three different paint-types were chosen because of their different chemical base, and because of their content of harmful substances. But the paints are not considered being more harmful than average and two of the systems are sold as environmentally sound alternatives.

The types of paint used were waterborne oil emulsion paint, waterborne latex paint and waterborne distemper paint, all with a red pigment (a common choice in Sweden). In Table 1 the content of eco-toxic substances in the three paint types are displayed. The tests also included a solvent-based alkyd oil paint originally, but there was a great problem finding ways to analyse the toxic substance in this paint, i.e. tolylfluanid, due to the low detection level needed. Therefore, the results of the alkyd oil paint is not included in this publication.

Table 1 Content of environmentally hazardous substances in the tested paints.

Paint type	Compound	Content in paint [%]	LC_{50} [1)] (rainbow trout)	Exp. time	Reference
Distemper paint	Lead	N A	ca 0,20 mg/L	336 h	AQUIRE/EPA
Oil emulsion paint	Jodocarb (3-Jod-2-propynylbutyl-karbamat)	<0,1	ca 0,070 mg/L	96 h	AQUIRE/EPA
Latex paint	5-Chloro-2-methyl-4-isothiazolin-3-one	<0,0015	0,253 mg/L	96 h	AQUIRE/EPA
Latex paint	Kathon (2-Octyl-3(2H)-isothiazolin-3-one)	<0,1	0,0655 mg/L	96 h	AQUIRE/EPA
Latex paint	1,2-Benzisothiazolin-3-one	<0,05	0,016 mg/L	96 h	AQUIRE/EPA
Latex paint	Bronopol (2-Bromo-2-nitro-1,3-propanediol)	<0,05	18 – 24 mg/L	96 h	AQUIRE/EPA

1) Lethal dose for 50% of the population after a given time of exposure

Three specimens of wooden panelling sized 195×63 cm were painted with the recommendations specified for each paint type, except that no pre-treatment was used. The pre-treatment was not considered to influence the leaching noticeably. The system for the oil emulsion paint consisted of a solvent-based primer that had to dry for two days before the oil emulsion paint was applied. The latex paint was also painted two days after application of a solvent-based primer and after another day a second layer of the top coating was applied. Finally, the traditional Swedish paint system with the distemper paint had a primer consisting of the topcoat paint diluted with 20% water. After drying the top coating was applied two times.



Figure 1 Test wooden panels coated with four different paints.

The panelling specimens were placed outdoors during one month (November), at the rainy Gothenburg coast. During this month the rainwater passing the panels was collected and chemically analysed to see if substances present in the paint film could be detected in the run-off water.

Experiments were also made with solid samples, to see if the content of certain substances in the surface had changed during exposure. The exposed panels were analysed chemically using

LA-ICP-MS (Laser Ablation - Inductively Coupled Plasma - Mass Spectrometry) to be able to compare the concentration of trace elements at a certain surface depth.

This makes it possible to see if the surface has lost a substantial amount of the compound during the exposure to rain, by measuring the intensity of some trace elements in the paints. For example, brome was used as a trace element for finding bronopol in the latex paint. Unfortunately it is not possible to use the same test specimen for analysis before exposure and after, as the laser destroys the surface. The results are therefore entailed with an uncertainty; to have ideal background conditions for the experiment, the wood should have identical surfaces on the two specimens, and the content of analysed elements should be finely scattered over the surface.

Weather data for horizontal and vertical rainfall, temperature, wind direction and wind speed was measured during the whole month and reported via modem every 24 hours. Table 2 shows that November was a mild month without frost nights, but with a heavy precipitation. Table 2 also shows that the water from the panelling was collected during four times: after 6 days, 15 days, 20 days and finally 33 days after the first day of exposure. All of the rain in contact with the panels was collected and analysed.

Table 2 Average weather data during the four test periods.

	Test period	Wind speed, average [m/s]	Wind direction, average	Horizontal rainfall [mm]	Temperature average [°C]
1	1 Nov – 7 Nov	6,22	S.E.	25,8	8,82
2	7 Nov – 16 Nov	5,52	S.S.E.	50,0	8,3
3	16 Nov – 21 Nov	6,21	E.S.E.	59,8	6,53
4	21 Nov – 4 Dec	5,88	S.W.	54,9	7,65

3. RESULTS AND DISCUSSION

3.1 Analysis of surface

The results from the LA-ICP-MS surface test are displayed in Figure 2, Figure 3 and Figure 4 and in Table 3 for trace elements in the paints. Iodine was used as a trace element for the biocide jodocarb, brome was used for tracing bronopol in latex paint, and chlorine was used for 5-Chloro-2-methyl-4-isothiazolin-3-one, also in the latex paint. Lead is present in the distemper paint and could be measured directly.

To be able to se whether or not the compounds are washed off the surface, the results from the LA_ICP-MS must be quantified. The raw-data comes out as an intensity of the selected element before and after exposure of rainwater. The results were quantified by calculating the area under each curve given from the analysis (see Figure 2, 3 and 4) and divide with the time for measuring the surface (between 30 to 80 seconds), to have an average intensity. The difference in the average intensity is shown in Table 3. It is clearly shown that the measured substances are reduced at the surface after exposure. As much as 58% differed between the exposed and unexposed surface containing brome from the biocide bronopol, as seen in Figure 2. For some substances there was great differences between the two surfaces examined

on the same wooden specimen, which is explained by the difficulty to make a test with ideal conditions; the substances are not distributed enough evenly on the wood surface, and the wood surface itself could be different on the two different areas.

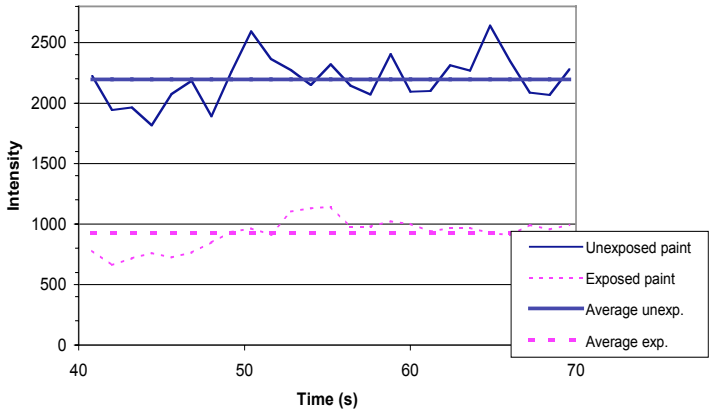

Figure 2 Change of brome-content in the latex paint, before and after exposure to rain. The average content had decreased with 58,0 %.

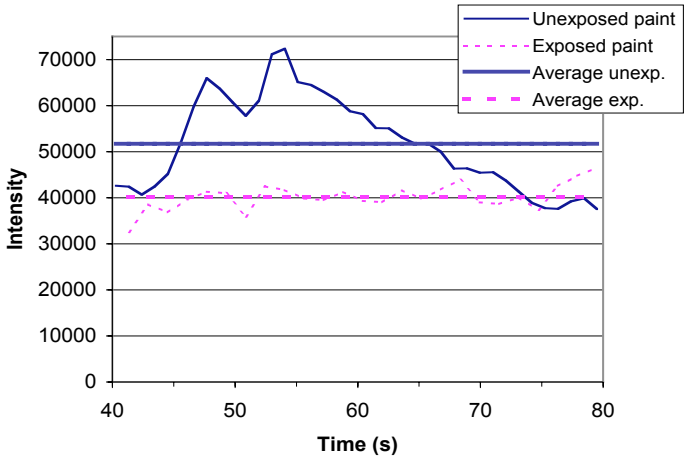

Figure 3 Change of lead-content in the distemper paint, before and after exposure to rain. The average content had decreased with 53,6 %.

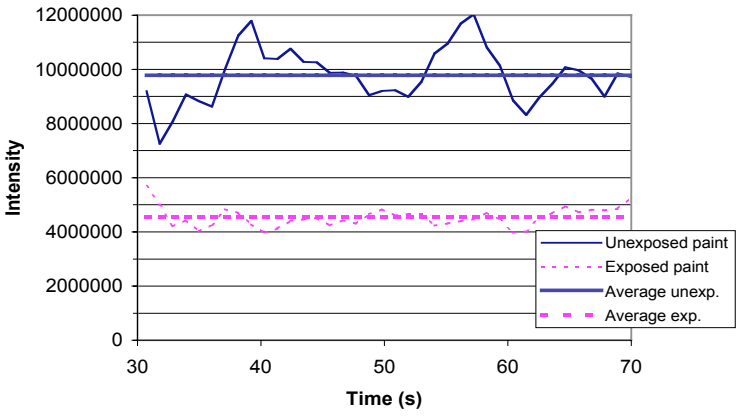

Figure 4 Change of iodine-content in the oil emulsion paint, before and after exposure to rain. The average content had decreased with 22,3 %.

Table 3 Average difference in intensity between exposed and unexposed painted wooden panels. The intensity is measured in the surface at two different areas on each specimen, A and B, with LA-ICP-MS.

	Brome- in latex paint [%]	**Chlorine** – in latex paint [%]	**Lead** - in distemper paint [%]	**Iodine** [%]
Test in area A	- 52,3	- 12,0	- 32,9	0,0
Test in area B	- 57,9	- 21,3	- 53,6	- 22,3

3.2 Analysis of leaching water

The content of substances in the run-off water was, naturally, at the most when the paint was newly painted, see Figure 5. The result is displayed as the concentration of bronopol and jodocarb, instead of the trace elements brome and iodine, as it was shown by reference tests that the content of brome and iodine in the rainwater was very low. The concentrations for the two substances were calculated using ordinary stoichiometry.

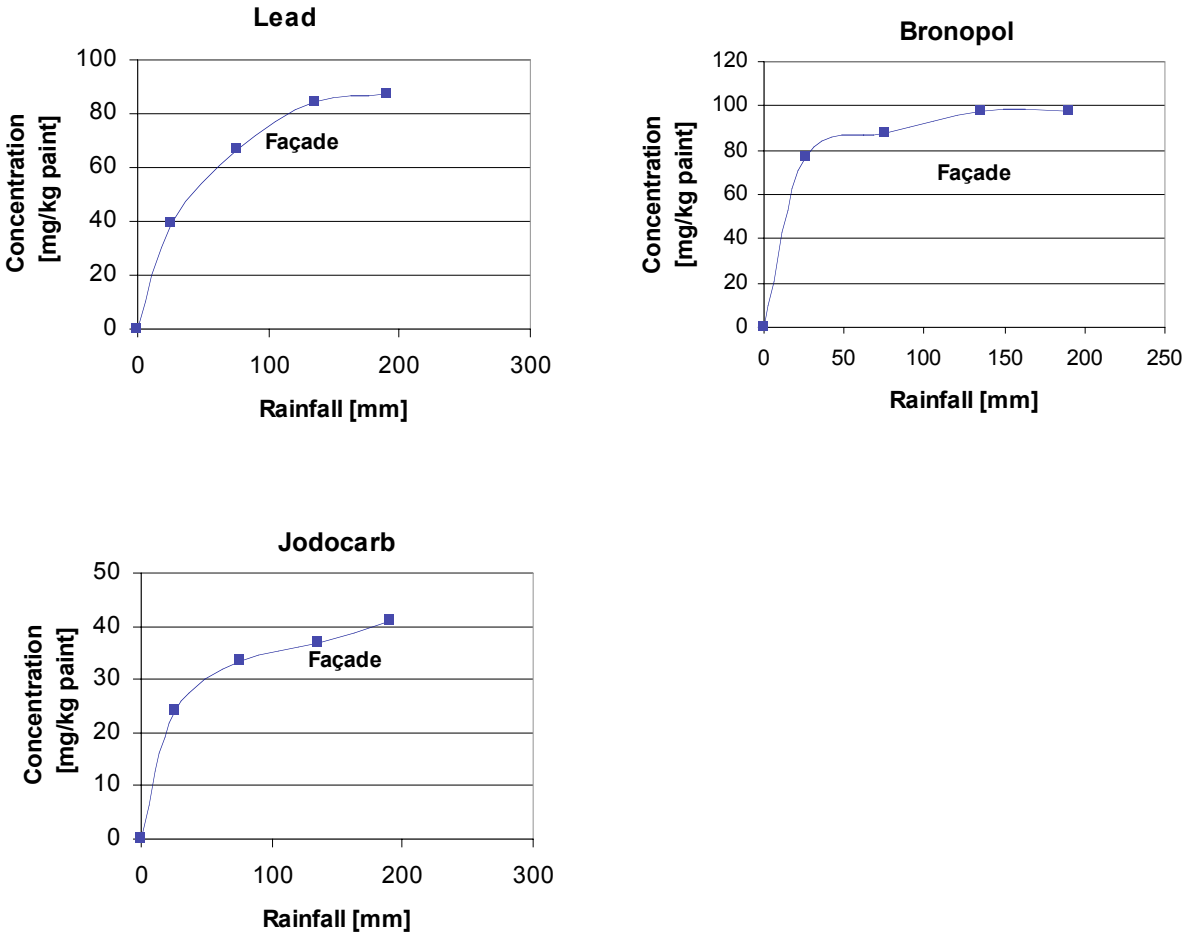

Figure 5 Leached amount of the trace elements lead, brome (for bronopol) and iodine (for jodocarb), per kg paint. The test period was 33 days, during which it rained 190 mm.

In table 4 the results are shown for each leach period. The first leaching period gives very high concentrations for jodocarb and lead, if compared with LC_{50}-data. Bronopol, a much less toxic substance is on the other hand never close to its LC_{50} – value. Several other substances were also detected in high concentrations, among them cobalt and molybdenum. A rough estimate of the total amount of lead washed out from all distemper paint sold in a year in Sweden gives that approximately 375 kg is washed out every year, if assuming that the leaching during the whole year for all the sold paint, per painted square meter, is equal to the entire amount leached during the 33 days of this experiment, per square meter. For more information, see (Gebäck and Jansson, 2001) or contact the author.

Table 4

	Measured concentration in leachate [mg/l]				**LC_{50} rainbow trout [mg/l]**	
Leach period	**1**	**2**	**3**	**4**		
Jodocarb	0,94	0,18	0,05	0,083	0,05	(96 h)
Bronopol	3,39	0,32	0,19	0,005	18-24	(96 h)
Lead	1,86	0,66	0,29	0,072	0,20	(226 h)

4. CONCLUSIONS

Some main conclusions can be made from the results presented here.

Toxic substances present at low concentrations in ordinary façade paint is leached to the surrounding environment. This is shown by analyzing the run-off water from paint wooden panels and by laser ablation test of the painted surface. The following observations are notable:

- With LA-ICP-MS it was shown that more than 50 % of the intensity of brome at the surface was lost after exposure to rain, in two separate tests. For chlorine (and thereby the substance 5-chloro-2-methyl-4-isothiazolin-3-one), lead and for iodine (and thereby jodocarb) the difference before and after exposure varied between 0 and 54 %.
- The analysis of the leaching waters showed a high run-off the first week, which gave concentrations in the leachate that were higher than the eco-toxic dose which kills 50 % of the population of fishes (rainbow trout) after 96 h.
- After one month of exposure it is still possible to detect the substances in the leachate, even if the leaching rate is much reduced.

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Thermal Comfort; Operative Temperature in the Sun

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1. INTRODUCTION

Thermal comfort is an important issue in the indoor environment. The operative temperature is one of the main parameters that describe thermal comfort. The operative temperature is normally calculated as described *Thermal comfort Analysis and applications in environmental engineering*, P.O Fanger. In common practice today the operative temperature is measured and calculated for a location in the shade. Short wave radiation on the body due to the sun is not included. This paper proposes a method to include direct solar radiation in the evaluation of thermal comfort.

2. MEASURED THERMAL COMFORT IN AN OFFICE

A south facing office located in Oslo was chosen for measurement of thermal comfort with different shading devices. The office was equipped for one person and a 100 W heater simulated the person. The work place in the office is shown in figure 1. An operative temperature sensor is located at the desk in front of the PC. This location is close to where the person is located. In the back of the room where there is no sun we both measure the air and the operative temperature.



Figure 1 South facing office at SIEMENS Linderud. Measurement of operative temperature.

The office has 11 m^2 floor area and 3.6 m^2 glazing fazing south. The windows has clear double glazing with U-value: 2.7 W/m^2 , g-value 0,76 and light transmission 80%. One external and internal shading are installed. Measurements were performed in the office on sunny days without shading, with internal and external shadings. It is electrically heated and mechanically ventilated. Operative temperature at the workplace and in the back of the room were measured together with outdoor air-, ventilation inlet air and room air temperature and outdoor solar radiation.

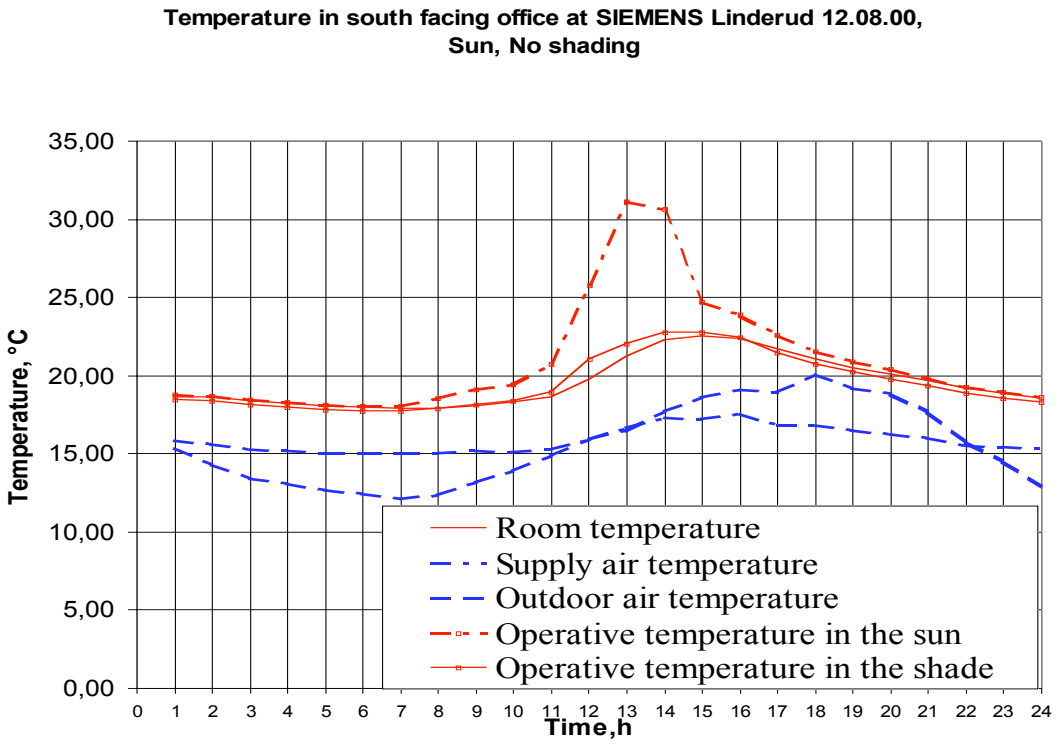
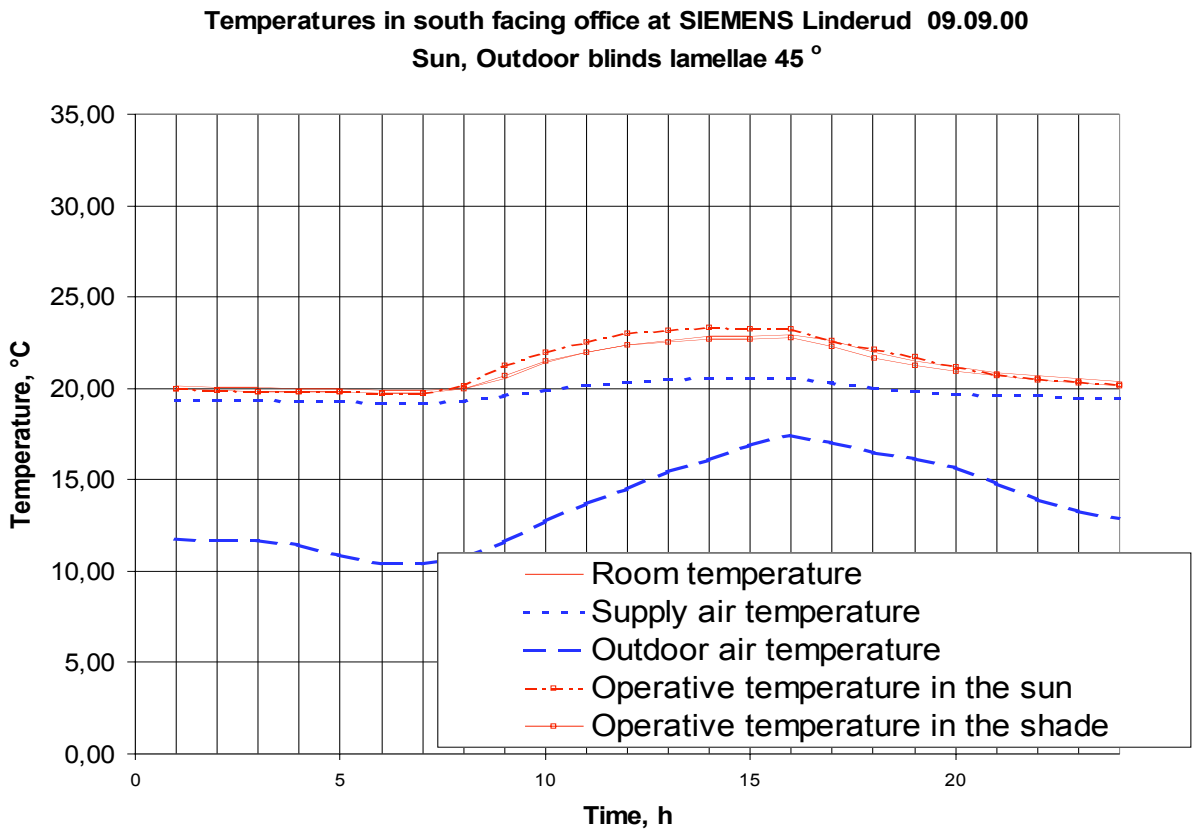
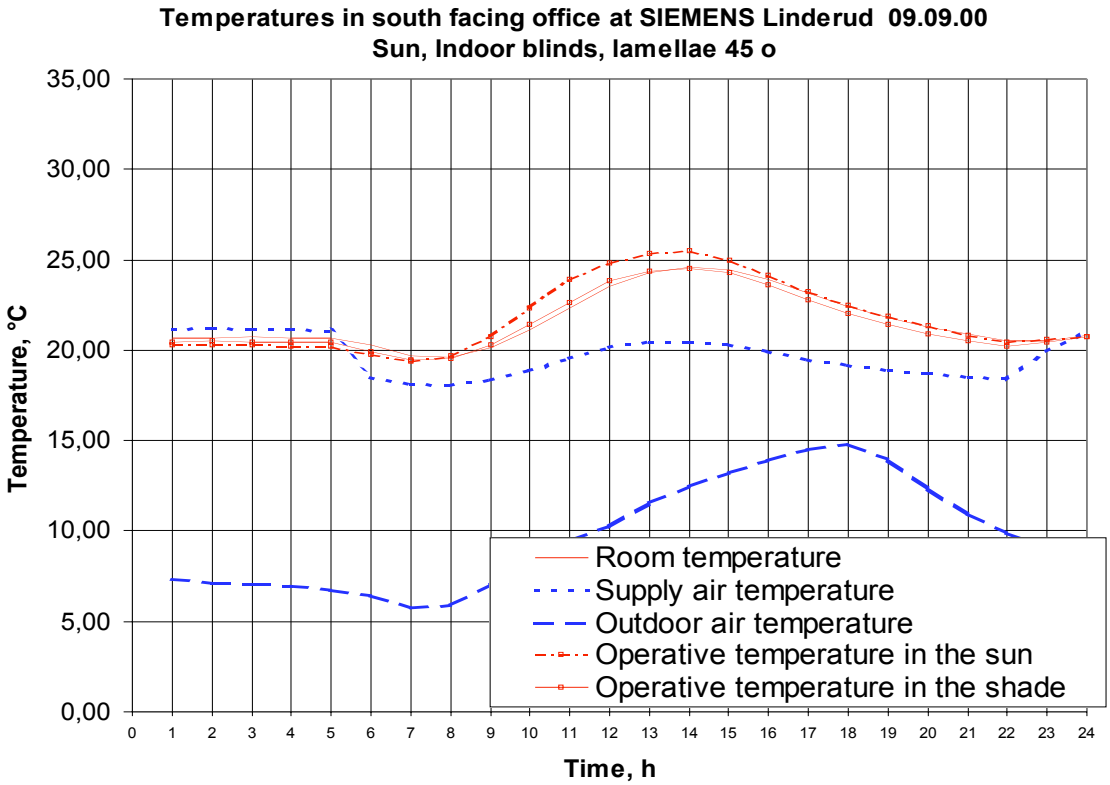


Figure 2 Temperatures in the office with no shading.

The temperatures are measured in the office with no shading in the middle of august. As we see the operative temperature at the workplace goes up to 31 ^oC. This will cause severe discomfort. At the same time the operative temperature in the shade is maximum 22.5 ^oC and maximum air temperature is 22 ^oC. When calculating thermal comfort only the operative temperatures in the shade is calculated in the existing calculation methods and simulation programs. By using common practice today the planners would calculate the operative temperature to be 22.5 ^oC and the air temperature 22 ^oC which mean it would be a very good indoor climate. The operative temperature at the workplace in figure 2 shows the reality. The operative temperature at the workplace is 8.5 ^oC higher than would be calculated. This also shows that the common practice today often may lead to poor thermal comfort. We will here present a method to overcome this gap between theory and reality.



Figur 3 Temperatures in the office with outdoor shading with slats at 45 °



Figur 4 Temperatures in the office with indoor shading and lamellae slope at 45 ^{o}.
In Figure 3 we see the operative temperatures and the air temperature in the room is measured on a clear sunny day the 09.09.00. During this day the outdoor shading was used. These measurements shows that the operative temperature at the workplace will be 23 ^{o}C while the operative temperature in the shade and air is equal and 22.5 ^{o}C. The difference between the operative temperature at the workplace and in the back of the room is now only 0.5 ^{o}C. The reason for this is the difference in direct solar radiation at the workplace for the two cases.

Figure 4 shows that the operative temperature at the workplace is 1 ^{o}C higher than the operative temperature in the shade with interior blinds. This means that we for this situation has a slightly higher direct solar radiation than the case with the outside shading

3. CALCULATON OF OPERATIVE TEMPERATURE IN THE SUN

In this project we were interested in finding a way to calculate the operative temperature in the sun. If we could calculate this temperature it will be easy to say something about the indoor environment when no shading or curtains is used.

P.O. Fanger describes a calculation of the mean radiant temperature for a person who is affected by a high-intensity radiant source. In our case the sun is a high intensity radiant source. We can then use his equation to calculate the mean radiant temperature with influence of radiation:

$$T_{mrt} = \left(T_{umrt}^4 + \left(const \cdot f_p \cdot \alpha_{ir} \cdot q_{sun}\right)\right)^{0.25} \qquad [1]$$

where,

T_{mrt} – total mean radiation temperature included sun radiation [K]
T_{umrt} – radiation temperature without sun contribution [K]
const – 1/(0,97*σ)
σ – 5,77*10^{-8}, Stephan Boltzmans constant [W/m²°C^4]
f_p – projected area factor
α – Absorption factor

q_{sun} can be found like this:

$$q_{sun} = \frac{I_h}{\sin\theta}\alpha_k \qquad [2]$$

where

I_h – Global horizontal radiation [W/m²]
θ – Angel of incidence [°]
α_i – shade factor or **direct solar transmittance**

When the mean radiation temperature is found, t_{mrt} is used to calculate the operative temperature in the sun, by using this relation:

$$t_{optsun} = \frac{t_a + t_{mrt}}{2} \qquad [3]$$

where,

t_a – ambient air temperature [°C]

Equation [3] is valid when the air velocity is below 0,4 m/s and when the mean radiation temperature is below 50°C.

4. EXAMPLE

In the calculation of the mean radiant temperature from Fanger, equation [1] we had to make some assumptions. The projected area factor, f_p, is an area factor. Fanger describes, in his book, this factor with relation to a seated or standing person. In our case we have a globe, and an area factor for a globe will be $f_p = A_s/A_k$. Where

A_s – area of a circle
A_k – area of a globe

The equation that is valid for this case is

$$A_s = \frac{\pi}{4}d^2 \qquad [4]$$

$$A_k = \pi d^2 \qquad [5]$$

This results in an area factor for a globe at 0.25. If we uses data from Fanger's diagram for seated person, for an altitude at 60° and an azimuth at 0° we get a projected area factor at

0.26. We decided to use the area factor for a globe in our calculations, so we where nearest to our measurements. The absorption was set to 0.85, since a black globe was used to measure.

In our project we measured the global horizontal radiant, Ih, from the sun. The measurements were worked through 12.08.00. We measured I_h = 889 W/m² at 2:00 pm. When we calculated the theoretic sun we got I_h = 681 W/m². The measured value here is over the theoretic possible value and we suspect that our measurements are too high. We assume the reason for this can be the placing of our instrument. It may have been exposed for considerable reflections, which lead to higher values of radiant than expected from the sun. For this reason we have used theoretic sun in our calculations.

f_p – = 0,26
α – = 0,85
α_i – = 0,69 (direct solar transmission of glass)

Time	Measured Air Temperature T_a °C	Measured Operative Temperature T_{opt_shade} °C	Calculated I_h, global horizontal rad. W/m²	Calculated Incidence Angle °	Calculated Solar radiation q_{sun} W/m²	Calculated Radiant temperature $2*T_{opt_shade} - T_a$ T_{umrt} °C	Calculated Mean radiant temperature from (1) T_{mrt} °C	Calculated Opt temp in the sun from (3) T_{opt_sun} °C	Measured Opt temp in the sun T_{opt_sun} °C
1.00 pm	21,2	22,0	730	57	872	22,9	42,8	32,0	31,1
2.00 pm	22,2	22,7	681	68	736	23,2	40,2	31,2	30,7

At the hours 1:00 PM and 2:00 PM, when the weather was bright, the measurements and the theoretic calculations are quite similar. The measured temperature is slightly lower than the calulated. This may be caused by inexact direct solar transmission of the glass as the data used was taken from a catalogue. This leads us to believe that this method can be used to calculate the operative temperature in the sun. It also shows that operative temperature in the shade is not a correct measure for thermal comfort.

To calculate the operative temperature in the sun we first calculate the operative temperature in the shade with a building simulation program where we use the g-value for the facade component. Then we calculate the operative temperature in the sun with the method described here where we also need the **direct solar transmission**. We therefore also need to know the direct solar radiation to compare to facade products.

We suggest that the method should be verified in laboratory tests where data on glazing is available and surroundings are controlled.

5. CONCLUSION

We wanted to find a method to calculate the operative temperature in the sun. By using Fanger's theory about high-intensity radiant source we have found a method to calculate the mean radiant temperature for persons exposed to high radiance. In our calculations we saw

that the calculated and the measured operative temperature was similar. This shows that this method can be used for calculating the operative temperature in the sun.

The results also show that operative temperature in the shade is insufficient to determine thermal comfort. We need also to calculate the operative temperature in the sun.

The g-value is insufficient to describe the solar properties of a facade product. **Direct solar transmission** for the glazing and shading together is also necessary.

Since our measurement of the global horizontal radiant is not reliable there will be necessary with a control of the method with new measurements. New measurements are planned in the near future that will be used to support the method described in this note.

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Strategies for sustainable building and urban development in Malmö; exemplified by Västra Hamnen and Augustenborg

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1. INTRODUCTION

This paper presents strategies for sustainable building and urban development, based on experiences from two projects in Malmö, the Bo01 area in Västra Hamnen and Ekostaden Augustenborg. It first presents a basic outlook on sustainable urban development in the city of Malmö, as a base for the strategies implemented in the projects. It argues that one has to look upon the projects as a whole, consisting of a package of measures. The measures are undertaken in different focus areas such as energy, ecocycle, traffic and biodiversity, resulting in a sum greater than the parts. The paper gives a strategic background, describes the two different projects and finally concludes with strategies for further development in the city, based on the experiences from the projects and new models for cooperation and implementation.

2. BASIC OUTLOOK

The city of Malmö has developed a strategy for sustainable development based on general documents such as the Local Agenda 21 Plan and the Environmental Strategy. The LA 21 plan taken in 1997, documents the state of the environment in the city and describes the visions for sustainable development. The Environmental Programme laid down in 1998 sets up concrete goals to reduce climate impact and the use of resources, both in buildings and everyday city activities. Simultaneously the Swedish government initiated a major funding programme for sustainable investments in the municipalities, which made it possible to develop a tool to reach these goals, Malmö's Local Investment Programme for Sustainable Development.

Malmö has through its density, geographical situation, good infrastructure, and other favourable conditions, possibilities to become a very resource efficient and sustainable city. There are, for example, unique possibilities for large-scale systems for locally renewable energy from the sun, wind, water and bedrock to be combined with effective systems for district heating and cooling. Strategies where measures for ecological, social and economic sustainability can be combined are necessary to create a sustainable development of the community as a whole.

3. EXPERIENCES FROM MALMÖ

Sustainable building and urban development have been the focus in two different projects in Malmö. One is an existing housing area where the focus has been sustainable revitalisation and the other is a redevelopment of a former industrial area to a new city district with high environmental aims.

3.1 Ekostaden Augustenborg

Augustenborg was built in the post war period as a pioneer of the new Swedish housing policy. Construction started in 1948. The area gained international acclaim in Sweden and Europe as a model of future urban living, and consisted of high quality accommodation, schools, shops, local employment, social facilities and a pleasant environment. During subsequent decades industrial decline and associated social and economic problems have hit the area hard.

A number of different departments within the City of Malmö, Fosie SDF, the local city borough, and the municipal housing company MKB initiated the Ekostaden Augustenborg project and have been working together with local residents to revitalise the area, to make it a more socially, economically and ecologically sustainable neighbourhood. The project is partially financed through Malmö's Local Investment Programme for 1998-2002. Ekostaden Augustenborg is one of Sweden's largest urban sustainability projects, covering the residential area, the school and an industrial area. The aim is to create a higher degree of resident's participation and jobs locally, and to make the area a model for similar revitalisation projects in Malmö and Sweden.

3.1.2 Sustainable building: the original character of the buildings had been damaged in the '70s by covering the facades with external insulation and steel sheeting. this also has had a negative effect on the internal environment in certain houses with problems with damp, ventilation and temperature control. this covering of the walls has been removed and a new insulation layer has been covered with skimmed painted render in five buildings, the remaining to be done in a rolling programme over a longer period.

Thirteen resource houses have been erected with sound materials and green roofs, one of them with straw and clay walls. The school has a new demountable ecological pavilion, with solar panels and a urine-separating compost-toilet. A communal house for the elderly has been built with sound materials and a green roof, as an extension to an older building now adapted for people with mobility problems, and a new house with flats for the elderly has erected on the unsightly concrete roof of a large underground garage.

9000 m2 of green roof has been created on Kommunteknik's industrial area. The roofs form a unique botanical roof garden, where Europe's most comprehensive multidisciplinary research and development programme on different aspects of green roofs is carried out.

3.1.3 Green structures: the large green roof project is a part of both rainwater management and the green structures. the area had problems with flooding of the cellars in heavy rains. as the roofs of the industrial area were a large rainwater-collecting surface, applying the green roofs minimises runoff and the new rainwater management system starts here. elsewhere in the area the rainwater is led in into a series of open channels collecting the run-off from most of the hard surfaces, taking it into holding and flooding ponds before the water leaves the area. the actions taken will ultimately result in a 70 % decrease in the run-off water that leaves

the area. the courtyards and augustenborg's park have been redeveloped together with the residents. the ponds and new planting also contributes to biodiversity.

3.1.4 Eco-cycle, waste management: the residents recycle nine fractions and compost organic waste in huge compost machines in the new resource houses placed within a short distance from the flats. this action means that ultimately 80 % of the waste from augustenborg will be collected and recycled or reused. an ecological management plan for the area has been developed that contains waste handling, composting of garden waste and a fossil-fuel free machine park for maintenance of the common green areas.

3.1.5 Traffic: the world's first electric road train is operating in the area providing a link between outlying areas and a central bus depot and local services such as health centres, chemists and banks. traffic in the area has been a problem and speed limits of 30 km/h have been introduced. a car pool with electric and ethanol powered vehicles has been started by a group of residents.

3.2 Västra Hamnen, the Bo01 Area

The City of Malmö has started redevelopment of Västra Hamnen, an old industrial area in the harbour, to a new city district with apartments, offices, shops and other services. Västra Hamnen used to be the centre of industrial activity for over 100 years for amongst others Kockums, the local shipyard, where huge boats and later submarines were built. In the late '80s SAAB built a new modern car factory on the landfill area, but the area has been left empty after changes in industrial activity.

Bo01, City of Tomorrow, the European Housing Expo in 2001, is the first step in redeveloping the area. The theme for the expo was "The future city in the ecological sustainable information and welfare society". A number of pioneer projects and special solutions work together to reach environmental sustainability for the area as a whole. The aim for the district is to be an internationally leading example of environmental adaptation of a densely built urban area.

The project was possible to realise to the full through grants from the government through the Local Investment Programme for Malmö for the period 2000-2003. In the project a Quality Programme agreed upon between the city, the expo and the developers, set standards for materials, energy efficiency, and biodiversity. System solutions for waste, sewage, traffic, energy and biodiversity were accomplished by the application of existing technology combined in innovative ways.

3.2.1 Soil decontamination: as the area has been the centre for industrial activity and consists of landfill from construction work and building in the city, the ground has been examinated and comprehensive ground works have been carried out to ensure there is no risk for health and the environment. a small portion has been removed and deposited awaiting treatment.

3.2.2 Sustainable building: all houses have been built based on standards set in the quality programme. the city of malmö, the expo and the contractors have agreed upon standards for the buildings performance concerning material use, energy and green issues. environmentally dangerous substances are avoided. the standard for energy use in the buildings is set to 105 kwh/m2 annually. there have been high ambitions to combine ecological sustainability with human sustainability in the shape of good architecture, beauty, social interaction and

functionality. the large number of contractors and different types of buildings makes it possible for the area to show a great variety of architectural designs and solutions on sustainable building.

3.2.3 100% local renewable energy: The area is provided exclusively with energy from renewable resources. Sun, wind and water are the basis for energy production together with biogas from refuse and sewage from the district. Electricity is generated mainly by wind power with a minor part generated by photovoltaics. A new wind turbine provides electricity for 2000 flats.

A large percentage of the heating is extracted through heat pumps from aquifers (natural water reservoirs in the bedrock) and seawater and also generated from solar collectors. The areas energy system is connected to the city's energy grid as a storage and reserve supply. This means that the local system exports energy when it is producing a surplus, and imports when the opposite is the case. On an annual basis the system is producing the amount of energy needed in the area. The system consists of existing technology combined in an innovative way. The concept has been rewarded with EU-Commission's energy prize "The Campaign for Take-off Award."

3.2.4 Eco-cycle, Waste treatment: Collecting stations for 6 fractions are located in the properties. These fractions go to recycling plants. The organic and the other waste fraction go into vacuum waste chutes. The organic waste is taken from there to the biogas plant, where it meets slurry from food waste disposers in 70 apartments, and sewage. The biogas can be used as alternative car fuel, for electricity and heat production, or be pumped back into the area's natural gas grid after further cleaning. The next step in the process will be a KREPRO plant where phosphorus is extracted from the sludge from the biogas process. The remaining waste is taken to Malmö's waste incineration plant where heat is extracted. The area is attached to Malmö's existing sewage system, except for the food waste disposers that have separate pipes to the collector tank.

3.2.5 Biodiversity: The district is built with the aim of containing a diverse range of natural life. A number of habitats are created in the parks, and green space factors and green points are used to stimulate biodiversity in the housing area, resulting in green roofs and a variety of gardens.

Rainwater is treated locally without any connection to the public sewage system and will be cleaned and treated through a surface run-off system. The system consists of green roofs, channels and dams that hold back the rainwater before reaching a recipient, either the canal or the Öresund. The system also contributes to an increased biological diversity in the area.

The green space factor system is used to integrate the design of the houses with the gardens. The system is applied to ensure compensation for land use and biodiversity in the area. 14 different factors have been set up, and the project has to reach a factor of at least 0,5 to get building permission. The building contractors have also selected at least 10 "Green Points" that benefit biodiversity.

3.2.6 Traffic: the area is planned and built to give priority to pedestrians, bicycles and public transport and to minimise effect on the environment from traffic. a mobility management office is set up to give residents and companies in the area advice and support. a transport-

pool with alternative vehicles has been set up, and a station for electric charging and gas filling is placed in the area.

3.2.7 Environmental communication and IT: through information, advice and different experiments with it-solutions one aims to motivate and facilitate environmental sound behaviour and actions. the inhabitants shall be able to read and control their own energy consumption and book a car in the carpool.

4 STRATEGIES FOR FURTHER DEVELOPMENT

The City of Malmö is working towards creating a collected operative strategy for sustainable building and urban development. The purpose is to develop a toolbox with different tools and strategies.

One strategy is to develop methods and work procedures to work locally within defined areas. Success factors to succeed with this type of local work is amongst others the ability to:

- Create commitment and local co-operation between individuals, organisations and companies.
- Find resources for investments and development work
- Combine local ideas and wishes with knowledge and experiences from different professional participants
- Work methodically with long term aims and determination, which requires experience and patience.

Another strategy is to develop governing programs and criteria, for example:

- A Programme for ecological building
- Local environmental and quality programmes
- Green space factors and similar criteria

A third strategy is to develop a new type of environmental management system that could be used in new development or ecological redevelopment of residential areas. The experiences from Bo01 and Augustenborg should be the basis for this.

A forth strategy is to create a local centre for sustainable urban development. This centre could be a platform for partnerships between different actors on the scene and for research and development of future sustainable solutions.

5. CONCLUSION

The work towards sustainable development has been carried out together by a large number of participants in both the Bo01 and Augustenborg projects. A number of research projects are following up the different measures taken. The experience from the projects make a common ground to build on for continued work towards a sustainable building practice and development in Malmö. They reflect two urban settings that are both important to deal with, the construction of new urban areas and the revitalisation of existing housing areas. Experience from the pioneer projects in new construction can be implemented in the existing building mass, and the Augustenborg project shows an approach that can be developed further in other existing areas.

The experiences from these projects will be a model for further sustainable development projects. The high environmental standards set in the Bo01 area will be followed up in the further development of Västra Hamnen, through a revised Quality Programme and similar

infrastructure projects. A project to introduce solar energy in Augustenborg has been developed, based on the experiences from Bo01. Lastly, a Programme for Sustainable Building in Malmö is underway, to be applied in new residential projects.

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Indicators as a Planning Tool for Urban Residential Areas

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1. INTRODUCTION

This paper deals with the development of indicator systems for the assessment of an urban residential area and the application of this theory to the City of Malmö. It first introduces some theoretical background to indicator theory. Then, the methodology that was used to develop the indicators in this case is explained, followed by a brief evaluation of the usefulness of the methodology and the resulting set of indicators based on the experience gained through the practical application. Some recommendations are made with regard to the implementation of indicator analysis in the urban planning context.

2. THEORETICAL BACKGROUND TO INDICATOR THEORY

Indicators provide a structured assessment tool, assessment of the current situation and assessment of the future situation and development. Thereby they can be used as part of a steering mechanism which makes it easier to implement the idea of continuous improvement in practice.

"Indicators are basic tools facilitating public choices and supporting the implementation of policy decisions. They help:

- to provide quantified information on relevant contexts and issues;
- to identify development potentials, problems and perspectives;
- to analyse and interpret actual or potential conflicts and synergies;
- to assess policy implementation and impacts." (OECD, 2001)

The use of indicators for evaluation is a very common method for the performance assessment of a wide variety of activities. A set of indicators is like a sieve which is used regularly to filter the same data sources and makes it possible to analyse possible changes over a time span. Obviously there can only be a limited number of indicators as otherwise the information and amount of data is too much and cannot reasonably be understood and processed. This brings with it two consequences: on the one hand it simplifies the environment and thereby makes it easier to process the information, on the other hand it is difficult to capture the truly relevant topics i.e. it is fairly easy to emphasise one issue too much or disregard another.

Indicator Theory

Assessment of sustainability is a difficult issue in itself, not only because of the different ways of defining sustainability and deciding what to consider important. A widely accepted way is to use the triple bottom line approach, i.e. to split up sustainability questions into environmental, economic and social aspects. This is what has been applied in this paper.

One indicator looked at individually is one lost number. It is not until the indicators are related to each other and are put into the context of their environment that the information can be interpreted and used. Systems Analysis can help by subdividing and structuring

relationships in the real world and thus between the indicators. It is difficult to include all the different aspects and interests that are interacting in cities. It can be seen that whenever indicator sets are developed, the person designing the set will always decide at least to some degree subjectively which of the aspects seem to be relevant and which ones are not. "While systems theory can provide a systematic framework for guiding the search for indicators (…) it cannot determine the final choice of indicators. This task remains to be completed by the investigators and it requires their subjective choice"(Bossel, 1999).
Another important aspect to consider is that of aggregation of data into one final number, which represents all collected data. By weighting the different aspects according to their estimated influence it is possible to accumulate all the information into one final number. This method makes it much easier to compare directly different situations. Although it is appropriate and useful in some cases it brings with it problems when applied to urban areas. Aggregating all data into one number is an oversimplification and gives only a vague impression of the bigger picture.

Following the principles and ideas of the above mentioned System Analysis it was tried to group the different aspects that were considered most important for a #sustainability assessment/sustainable development of city districts in Malmö.

3. APPLICATION IN PRACTICE: INDICATOR CLASSES FOR MALMÖ

Background for the development of the indicators is the Environmental Strategy of the City of Malmö. It had been developed in 1998 identifying eight main target areas, of which the target area 'Nature and the built Environment' served as the basis for the Indicator Classes used in this paper. The target area was subdevided into sub-groups. The three major ones ("Biological Diversity", "Recreation, Parks and a greener City" and "Integrated Planning Process") correspond to the indicator classes **A** ("Green Areas & Biodiversity"), **B** ("Transport") and **F** ("Resource Input and Output") respectively. The other minor action areas ("Water", "Soil Reclamation", Ecologically Sound Building", "Indoor Climate", "Radon" and "Electro-Smog") are covered by the indicator classes **F** ("Resource Input and Output") (first three) and **H** ("Health") (last three). In order to implement the triple bottom line, which not only includes environmental, but also economic and social issues, two more indicator classes were included. The class "Citizen Interaction" (**C**) represents the social issues, whereas the class "Income Available" (**D**) includes the economic questions.

Table 1 *Classification of Indicators*

Symbol	Classification	Explanation
A	Green Areas and Biodiversity	Density and access to recreational areas is especially important when planning a new residential area.
B	Transport	Transport provides the basis for the functioning of our cities, however should not become the major determinants in urban management
C	Citizen Interaction	Quality of life is at least partly influenced by social issues. Therefore keeping track of social matters makes an area easier manageable.
D	Income Available	In our society the economy is a major driver and is partly a reflection of the living standard in an area.
E	Health	Health determines the happiness of residents to a

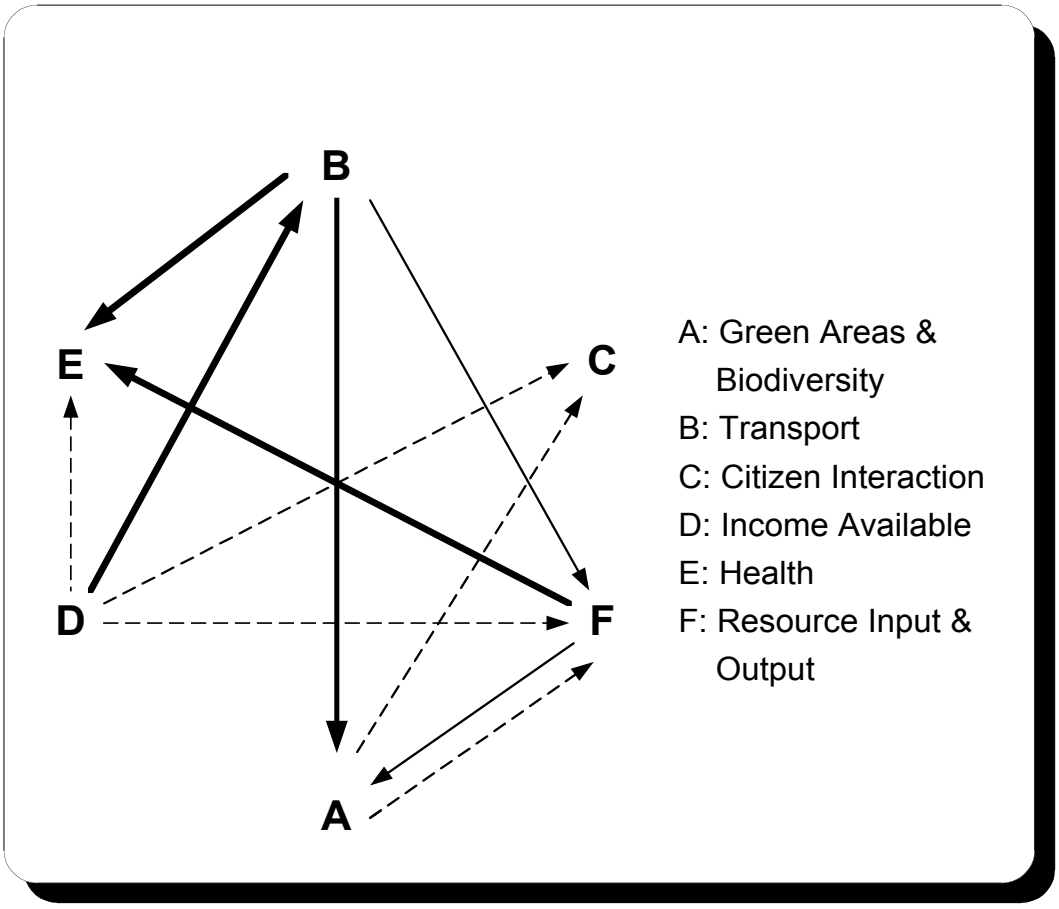
Symbol	Classification	Explanation
		great extend. Therefore improvements in this area will also improve other aspects of life.
F	Resource Input and Output	This class is a major factor of influence for most of the other classes. Furthermore this class reflects directly the environmental impacts of the actions of a city.

Many of the indicator classes are not easy to distinguish and that often there is a strong connection between the individual classes. This is shown in Figure 1 by connecting the different classes with arrows of varying width, thick lines indicating strong relationships and dotted lines weak relationships. For example, it is evident that there is a strong influence of the traffic class (**B**) on the health of citizens: the more traffic, the worse air pollution and consequently the residents' health. Equally, traffic management determines how much space is used for the infrastructure and thus not available for other land uses. There is also a dotted line between the available income and the health. It is obvious that there is a stronger relationship between those two, since the more money someone has the more he can afford to spend on health care. Yet the relationship between those two is not that evident for this study, i.e. from a city planning perspective the way the individual spends his money for his own lifestyle does not play too high a role.

Another relationship is the connection between Citizen Interaction and available income. Although it might look apparent that there is a relationship, it is not so easy to say in which way they interact. On the one hand, the more money a person has, the less he will interact with his environment. This is the case with rich neighbourhoods where for example the gardens around the houses are so big that people do not meet very often. On the other hand, wealthier people can afford more time off work thus giving them more time to interact with each other.

Certain indicators have been developed that capture these relationships between the indicators. Because they show the relationship between two or indirectly more clusters of ideas and drivers it is easier through monitoring to detect changes and influence development into the desired direction.

Figure 1



Relation of the Indicator Classes to each other

4. ANALYSIS: HOW USEFUL IS INDICATOR ANALYSIS?

The value of using indicators for the assessment of residential areas is that they provide a framework and therefore give a fixed procedure in a changing environment. It is therefore possible to follow the development over time and track changes. From a planning perspective it is like looking through a window onto a tree. The size of the window is always the same, the perspective stays the same and consequently you always see the same part of the outside world. In the middle of the window is a tree, it is a fixed object, always at the same place over time. However, the tree is exposed to its environment and responds to environmental changes. It grows leaves in the spring, flowers, develops fruit in summer, colours its leaves in autumn and sheds them in winter. Using indicators to assess changes over time is similar. The indicators make it possible to always look and focus at the same issues and concentrate on them. Where this metaphor does not fit indicator analysis anymore is that indicators need to be flexible. It is important to have a regular review of the indicator set to screen whether it still fits the current situation and whether it still focuses on the critical issues, which might have changed over time as well.

Limitations:

a. There are several limitations for indicators in the urban context. One of them is that cities are very complex, they evolved through the interaction of many different stakeholders, big and small, reflecting an incredible amount of different ideas. Each of these stakeholders are pulling and pushing in diverse directions and the city that we have today is the result of this process and equally this process will continue to happen

the same way in the future. It is impossible to capture all different driving forces, since first of all it is not always obvious which ones the actual drivers are. Once one driver was found, Murphy's Law will step in and this driver will shrink to nothing while being replaced by something else. This is where indicators will always lack behind. Finding appropriate areas where to apply them remains constantly a challenge. "If the indicators are not right, then no amount of measuring, reporting, funding, action, political will or evaluation will lead towards sustainable development" (Meadows, 1998).

b. A second limitation of using indicators is that in some cases it might be very difficult to find data for the chosen indicators. Time is one constraint but there are other constraints as well, such as lack of money or lack of incentives. However over time, i.e. once data for the same indicators has been collected several times, it becomes easier and quicker. It is also possible, and in fact recommended, to set up a procedure setting a framework of how the data should be collected.

c. Thirdly, after the indicators have been developed and the data collected and evaluated, the next step is to react to the findings, the action that should follow. If the indicators show that there is a continuous increase in CO_2 emissions over the years, it is necessary to implement policies or have some other kind of response. Otherwise the whole indicator analysis was useless. On the other hand, having the policies and regulations but not knowing where to apply them does not help either. Indicator analysis needs to go hand in hand with follow-up and resulting counteracting or enhancing measures.

5. CONCLUSION:

In spite of all these obstacles and disadvantages of indicator analysis, they do fulfil at least one important and essential function: they measure and thus make it possible to quantitatively and qualitatively monitor. It is more than likely that a newly developed indicator set contains many indicators that turn out to be impossible to apply. But that is up to the people that are using them and up to time to show which ones are valuable and which ones are not. What is important is to get some preliminary indicators to start the process and to get a basis for improvement.

To conclude, indicator analysis is a useful tool if one is aware of its shortcomings, not only when designing the indicator set but also when analysing the data. Indicators can be used to give a baseline figure or allow comparisons with other districts of the city. If the indicator set includes indicators that are general enough in scope and aspects, it is also possible to compare across different regions, thus allowing an evaluation of different cities and the planning approaches between different countries.

6. RECOMMENDATIONS FOR USING THE INDICATORS

It is usually not enough to use a few indicators or an aggregation of several indicators into one number, which could then for example be used to compare different projects. Up to a certain degree it is justifiable, however should be backed up by more indicators and data analysis. An aggregation of indicators into one value can only serve to track the coarse development, it is not sufficient to base important decisions on such a small number of indicators.
A second important consideration is what has already been mentioned above, that they need to be flexible, they need to be re-evaluated so that they are being updated to continuously fit changes in the environment or objectives. The selection of the indicators is always done on a more or less subjective basis, also in this case. A five-year time period seems the appropriate

time span for this, especially for high-priority indicators. The review of the indicators can also be seen as a chance to continuously increase the targets to improve performance over time. Especially in the Resource Input and Output Class a tightening of the levels does not seem to be too difficult to implement.

Recommendations:

1. Important decisions should always be based on an appropriate number of indicators. Too little indicators might give the wrong impression and be misleading.
2. Indicators should not be seen as static. They need to be revised and adopted to changes in the environment or the objectives for the area.
3. The targets set by the indicators should be tightened over time to improve performance.
4. Use Indicators from the Planning stage onwards.
5. Set the targets for the indicators after consulting all stakeholders.

Figure 2 Recommendations for the use of Indicators

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Benchmarking for Sustainable Urban Development in Malmö – Using a Structured Comparison as a Pre-Study

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1 INTRODUCTION

This paper presents the work with benchmarking for sustainable urban development in Malmö. The Bo01 project is the City's most recent attempt to visualise how sustainable development in urban residential areas can be interpreted. There are plans to benchmark the Bo01 project against other projects in order to enhance the work with sustainable urban development. The paper gives an overview of the concept of benchmarking and presents Malmö's work with benchmarking for sustainable urban development so far. Then, a structured comparison between different housing projects is presented, which is to serve as a basis for future benchmarking projects. The plans for benchmarking are discussed, and finally some conclusions are given.

1.1 Introduction to Benchmarking

Benchmarking can be defined as a *search for the best practices that lead to superior performance*. It means that an organisation compares its practices to another organisation in order to get ideas for improvements. Benchmarking was originally developed in the private sector, but it is also appropriate for e.g. development of new residential areas, since different projects perform comparable activities.

There are different types of benchmarking. It can, for example, be divided according to what is benchmarked. *Performance benchmarking* compares the actual performance, which is the result of the practices used, while *process benchmarking* focuses on the processes that lead to the desired performance and *strategic benchmarking* compares strategies used in different organisations. It is important to structure and analyse the own organisation's activities in order to benchmark them. For a benchmarking project to succeed, some prerequisites have to be fulfilled. The most important ones are *support from the top management* of the organisation, *understanding of the own organisation's processes*, a *willingness to change* the practices, *openness to new ideas* and *creativity and innovative thinking* when applying them to existing processes. Another important aspect is that the benchmarking should focus first on best practices/methods and then on performance data. It is not the measurement that should be the objective of the benchmarking, but an improvement of the own practices and processes. (Andersson, 1998)

1.2 Bo01 and the Use of Benchmarking

The Bo01 area is an entirely new, ecological district for dwellings as well as offices, shops and other services. It is the first development stage of the Western Harbour, one of Malmö's growth areas. A fundamental ecological approach to planning, building and construction is a

key tool in the creation of the district. The aim is for the district to be an internationally leading example of environmental adaptation of a densely built urban environment. It will also be a driving force in Malmö's development towards sustainability.

A broad scientific program will evaluate the Bo01-project in order to gain knowledge for similar projects. Benchmarking is one of the scientific tools which are being used in the evaluation process.

2 STRUCTURED COMPARISON BETWEEN PROJECTS – A PRE-STUDY

In order to find appropriate benchmarking partners, a pre-study has been carried out. The comparison is qualitative, and the data for all projects except the Bo01 come from secondary sources, the most important of which can be found in the reference list. Hence, the comparison cannot be used for statistical purposes, e.g. ranking the projects or investigating the relations between different measures or categories. Some requirements were set up in order to limit the number of projects in the pre-study. For example, only projects in north-western Europe were considered, they should be new-built and rather recently completed and they should focus on residential areas.

2.1 Results of the Comparison

The structured comparison included eight different projects in north-western Europe, including the Bo01 project. The following projects were studied: Bo01, Malmö (Sweden); Greenwich Millennium Village, London (UK); GWL-terrein, Amsterdam (Holland); Hammarby Sjöstad, Stockholm (Sweden); Kronsberg, Hanover (Germany); Nieuwland, Amersfoort (Holland); Oikos, Enschede (Holland) and Viikki, Helsinki (Finland). Altogether, more than 130 different measures have been implemented, which were structured in ten different categories: 'green areas and biodiversity', 'transport', 'citizen interaction', 'income available', 'health', 'resource input and output', the latter being further divided into 'energy', 'water', 'materials' and 'waste', and 'other'. For each category, the measures taken were commented and potential trade-offs were discussed. In Table 1 some of the most innovative measures are presented.

Table 1 Selection of some of the most innovative measures taken in the different projects. Note that some of the categories have been left out.

Measure taken	**Project**
Green areas and biodiversity	
Allotments on-site/vegetables can be grown in the area	Greenwich Millennium Village, GWL-terrein, Kronsberg, Oikos, Viikki
Brownfield development	Bo01, Greenwich Millenium Village, GWL-terrein, Hammarby Sjöstad
Green space factor is used to enhance biodiversity	Bo01
Parks or gardens with the ambition to preserve/enhance local biodiversity	Bo01, Greenwich Millenium Village, GWL-terrein, Hammarby Sjöstad, Viikki
Transport	
Businesses (for shopping/working) are located in the area or adjacent to it	All except Oikos
Public transport stops within easy reach from every home	Bo01 (planned), Greenwich Millennium Village, Kronsberg

Measure taken	Project
Tele-working facilities	Bo01, Greenwich Millennium Village, Viikki
Track-bound public transportation	Hammarby Sjöstad, Kronsberg
Citizen interaction	
Communication agency or similar for monitoring and promoting sustainable development in the area	Bo01 (only transport issues), GWL-terrein, Hammarby Sjöstad (planned), Kronsberg, Oikos
Involvement of residents in area management	Bo01 (planned), Greenwich Millennium Village, GWL-terrein
Large proportion of easy access dwellings for elderly and disabled people	Bo01, GWL-terrein, Hammarby Sjöstad (planned), Kronsberg
Special housing forms for people of different nationalities	Kronsberg
Resource input and output – energy	
Computerised home management system	Bo01, Greenwich Millennium Village, Hammarby Sjöstad (planned)
Energy supply based on 100% renewable energy sources (including waste heat)	Bo01, Greenwich Millennnium Village, Hammarby Sjöstad
Individual monitoring of energy consumption	Bo01 (partly), Hammarby Sjöstad, Kronsberg
Thermal bridges are avoided	Kronsberg
Training of involved parties	Bo01, GWL-terrein, Kronsberg
Resource input and output – water	
Grey-water recycling	Greenwich Millennium Village, GWL-terrein, Nieuwland, Viikki
Individual monitoring of water consumption	Bo01 (partly), Hammarby Sjöstad (planned), Kronsberg, Nieuwland, Viikki
Storm water from hardened surfaces is collected separately	All except Greenwich Millennium Village
Resource input and output – waste	
Individual monitoring of waste generation	Bo01 (planned), Hammarby Sjöstad (planned)
Network of repair and services	Kronsberg
Pre-sorting bins in the dwellings	Bo01, Kronsberg
Other	
Binding quality programme or similar, where environmental/sustainability targets are set	Bo01, Hammarby Sjöstad, Kronsberg, Oikos, Viikki
Multi-disciplinary planning team	Bo01, Oikos
Training of parties involved in environmental and/or sustainability issues	Bo01 (small scale), Kronsberg
Variety was achieved through involvement of many different developers, architects and landscape designers	Bo01, Kronsberg, Nieuwland

2.2 Discussion

The measures seldom clearly belong to only one category. For example, some of the measures mentioned in the 'green areas and biodiversity' category could just as well fit under 'water', and some 'citizen interaction' measures also contribute to improvements in the 'transport' category. Still, when summarising all the measures taken, it is clear that energy is the area where the most creativity has been mobilised. Income available, health and materials are the

areas, to which the least attention has been paid, and the other areas are somewhere in between, concerning the number of measures that have been implemented in each of them.

There are possibilities for connecting different material and energy flows within a residential area, i.e. create *industrial ecology* solutions. For example, waste can be digested to produce biogas, which can be incinerated for energy production, and heat content in wastewater can be utilised as an energy source. One model for industrial ecology has been introduced in the Hammarby Sjöstad project. This is not to say that this model is the only way of achieving industrial ecology, or even that it is always desirable to strive for industrial ecology solutions. It should be noted, though, that such solutions cannot be seen from the structured comparison of measures. Furthermore, industrial ecology possibilities seem to have been neglected in many of the studied projects.

Although no quantitative data have been used in the comparison, it might be of interest to investigate which of the studied projects have implemented the most innovative solutions in the different categories. From the comparison of all measures taken, the Kronsberg and the Bo01 areas seem to be the 'best' of the studied projects in the category *green areas and biodiversity*. For *transports*, the measures implemented by the Hammarby Sjöstad and Bo01 projects should be highlighted. For *citizen interaction*, both Kronsberg and Greenwich Millennium Village stand out. *Energy* is the category with most measures implemented, and here, the Bo01 distinguishes itself for having implemented many of the measures. The Nieuwland and Viikki projects seem to have been successful in handling *water* issues. Finally, when it comes to *waste*, the Kronsberg area seems to have implemented the most innovative measures.

The measures found in the studied projects could be used to create a list of measures that should be implemented in future development projects, because they are reasonably easy to implement and gain high benefits. However, this is a rather static approach, which might not lead to superior performance in the long term. It would be better to identify the projects with the best procedures for finding innovative solutions and try to copy them. Thus, Malmö could establish a method of working with sustainable urban development, which would enhance the possibilities of finding innovative solutions specifically developed to suit the local conditions in Malmö.

3 FUTURE PLANS FOR BENCHMARKING IN MALMÖ

The ultimate objective of a pilot project like the Bo01 is of course to drive the development forward by making use of cutting-edge technology also in 'normal' housing areas. Through benchmarking it is possible to spread innovative solutions, and methods of finding innovative solutions, from several projects. The City of Malmö plans to develop the use of benchmarking as an evaluation tool of sustainable urban development in cooperation with invited stakeholders from different urban development projects. Different projects work under slightly different conditions when it comes to resources, national legislation, local preferences etcetera. However, despite the differences there are many similarities worth focusing on. The accumulated knowledge from the projects forms a vast source of information, which can be utilised by benchmarking.

There is also an ambition to extend the project to include existing urban areas. Since buildings have a long life span, already existing housing areas need to be regenerated in order to obtain sustainable cities. Benchmarking of regeneration projects could be used to improve the

performance of such projects, but also to generate ideas for new developments. Similarly, benchmarking of new projects can be used to generate ideas for existing projects.

4 CONCLUSIONS

An increasing proportion of the World's population lives in urban areas. Solving the problems related to an urban lifestyle is crucial in order to achieve sustainable development. A number of projects with far-reaching ambitions when it comes to ecological and social sustainability have been carried out in Europe recently. These projects can be used to generate valuable information for similar future projects. Benchmarking is one possible tool in the evaluation process.

There are notable results from the structured comparison between different housing projects. The pre-study also works as a first step towards the development of a framework that would make the use of benchmarking easier in the future.

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Key factors and indicators – how do we use them?

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1. INTRODUCTION

This paper describes the limitations of key factors and indicators as tools for comparative evaluation. The method to utilise key factors or indicators is increasingly being used when carrying out evaluations of sustainable housing projects around the world. This paper argues that these tools are necessary – but insufficient. All quantifiable figures have to be supplemented by a qualitative discussion and analysis in order to be valid.

Experiences from the urban ecology project Bo01, Malmö, Sweden, is the basis for discussion in this paper.

2. KEY FACTORS AND INDICATORS

2.1 Key factors

Key factors are chosen and constructed in order to represent important facts that can reveal something about the wider process of which they are a part. For example: a key factor for energy use could be the quantity of energy that has been used in each dwelling over a 12 month period. The figure obtained can give us summarised information about energy consumption. However, it says nothing about the context: how well insulated the dwelling is, how many electrical devices the tenants use or which temperature the rooms have.

Hence, the key factors must be very carefully chosen so that they really represent crucial information that can be "the key" to various other important facts and conditions.

2.2 Indicators

Indicators have been used by humans for generations. The sensitive birds that were brought down the pit shaft by miners reacted to poisonous gas long before the men showed any signs of toxic symptoms. Since then we have grown accustomed to the use of indicators in the field of nature conservation. Regular observations of the number of individuals of certain species present valuable information about tendencies of overall development.

Thorough measuring and counting can produce necessary evidence of change which can otherwise be difficult to ascertain: sphagnum moss only grows on every second tree in the forest of Tibble. Two years ago it grew on eighty percent of the trees. In nature conservation, indicators are invaluable and essential tools to provide evidence of important changes in the environment.

When using long-term measuring series, the observer gets clear indications about development trends. The figures themselves are of lesser importance, it is the conditions they reveal when compiled that is the primary benefit. The desirability of the development can first

be ascertained when this analysis has been carried out. If it is found to be negative, then different steps must be taken.

3. USING KEY FACTORS AND INDICATORS

When key factors and indicators are used as tools for benchmarking between urban projects, the situation is completely different than the one mentioned above. Here we are not revealing an imperceptible process in nature, but instead are analysing a planned and controlled strategy in order to obtain more sustainable neighbourhoods.

In this case the use of key factors and indicators has to be executed in another manner: a long series of observations must be undertaken with each urban ecology project representing one figure which by comparison could give us some information about the progress of efforts towards sustainability. Hence a question that has to be asked is whether we get accurate information or not. Can simple key factors and indicators tell professional architects or engineers anything really significant? Every new urban project is already planned with the knowledge of the techniques and solutions chosen for the previous one.

3.1 Governing with key factors and indicators

It is frequently suggested that governing could be made easier with the help of the use of key factors and indicators. Politicians and non-experts should supposedly be helped by these instruments to make wise decisions. Surely this would be beneficial, if it was the case. Unfortunately the processes and systems too often are all to complicated to explain in a simple key factor or indicator. The following will give examples of this.

3.2 Limitations of key factors and indicators

Quality aspects are extremely difficult to sum up in a figure or short conclusion but nevertheless it is the quality aspects that makes the difference between a successful project and a failure.

3.2.1 Example 1: green space factor. In Bo01, the housing area in Malmö, a *green space factor* was introduced, similar to the ones used in Germany. The aim was to attain as much foliage as possible in a dense housing scheme. The developers had to present a 0,5 green space factor to the authorities when applying for planning permission. This guaranteed that 50 percent of the plot would be “green”. Since the plan permitted buildings that covered more than half of the plot, all the developers chose to use green roofs and climbing plants in order to achieve the factor 0,5. An intricate system of points was created in order to make the green space factor work, and it included extra points for climbing plants, trees, hedges and even ponds.

During the housing expo Bo01 the green space factor was used as a key factor by a team of independent scientists. Different housing projects within the neighbourhood were compared with the help of the factor. The result was misleading.

A windy north-facing lawn in constant shadow got a higher score than a sunny little sitting area sheltered by foliage. A high *green space factor* did not necessarily mean that the yard was pleasant for human beings. It simply provided information as to how well the project used the system of points that had been created.

When it came to biological diversity the factor did not say anything about the quality of the yard. A group of landscape architects and biologists studied the gardens and came to the conclusion that the best project from this perspective was not the one with the highest factor. Evidently the *green space factor* was a perfect tool in order to get the developers to invest in foliage. But it was a useless tool for comparing the quality of the different gardens. Here you had to evaluate a number of different and important factors: shaded and sunny parts, windy and sheltered, places to sit and to play, biological quality and diversity, beauty of flowers and plants, the design of the gardens and the local rainwater run-off and how the water was used for ponds and small canals.

3.2.2 Example 2: energy efficiency. This example is also from the Bo01 benchmarking. Energy efficiency was a key issue at Bo01. In the quality program the standard was set high: a maximum use of 105 kWh per m2 and year. Almost all developers reported that they had achieved the goal. Some reported even lower figures. These were used as key factors and different projects were compared with each other, before anyone had started to live in the dwellings.

The problem is that the figure does not tell the whole truth. For one thing, it is only an estimated use of energy, but there are more complications and they are of a more serious nature. It is in the kitchen and bathroom that we use most energy in a flat. So if you have a small apartment it will be more difficult to reach the target. There are simply less square meters to divide the energy consuming parts between. So for a large family living in a small space it will be even harder, since the family uses a lot of energy for cooking and sanitary units. This will make it very hard to maintain a 105 kWh per m2 usage. Still we all know that compact living is the best way to save energy usage. Once again, the energy efficiency factor was an excellent tool to make the developers choose devices that were energy efficient and to insulate the buildings, but it is not a very good tool to use if you want to compare different objects.

Energy use per person would probably be a better way to compare. But here you have another complication: the figures will vary according to how many people are living in each unit at any given time. A family moves in and the kids leave home. After twenty years a single, divorced man may live in the flat.

3.2.3 Example 3: sun radiation. Once again Bo01 serves as an example. Window area was used as a key factor in order to get a value for solar gain. The method proved to be insufficient. Why? First of all, solar gain is affected by the construction of the window itself: how deep is the window surround, how many window panes are installed (each one lessens the solar gain) and finally, is the window pane clear or does it have a reflective coating? Secondly, the most important factor is whether the window is shadowed by other houses or not and if it is facing north or south. Furthermore, an international comparison is impossible since the sun is positioned very differently in the sky. The same window area will allow much more solar gain in Tanger than in Malmö.

Clearly, the dimensions of the windows is not sufficient information to calculate solar gain. Much more complicated methods are necessary to obtain a correct result and still something extremely important will be missed: the quality of the light when the sun's rays strike the floor tiles or the thin curtain. Is the light pleasant? Is it beautiful?

3.3 Risks when creating key factors

It is tempting to choose and create key factors that are easy to measure. The experiences from the examples above show that factors that initially were created for another purpose later were used as key factors and indicators. This had, of cause, never been intended. The risk of using the wrong key factors is evident, because it is extremely difficult to create factors that reveal facts about a much larger and more complicated system of facts and processes. What can be measured will be measured, and the rest might very well be overlooked even if it would have been the most important of parameters.

The strength and weakness of the key factors and indicators are their simplicity. They could, in the best of worlds, provide facts in an easy way, but they can just as easily oversimplify complicated processes so that they cannot be understood at all - merely misinterpreted.

It takes a very critical mind to construct factors. And there ought to be things that can be compared with the method. The most likely such factor can be *kilo garbage per citizen and year in each sorting fraction.* This could indicate the standards of the collecting system, or the quality of the assembly system, or the attitudes of the residents etc.

3.4 Using the key factors and indicators

Care is needed when using the factors for comparison. Each figure should be complemented with a discussion of their context and most importantly: they cannot be used in a simple table were they falsely give the impression that the highest score is the winner. This simplification ignores the quality discussion.

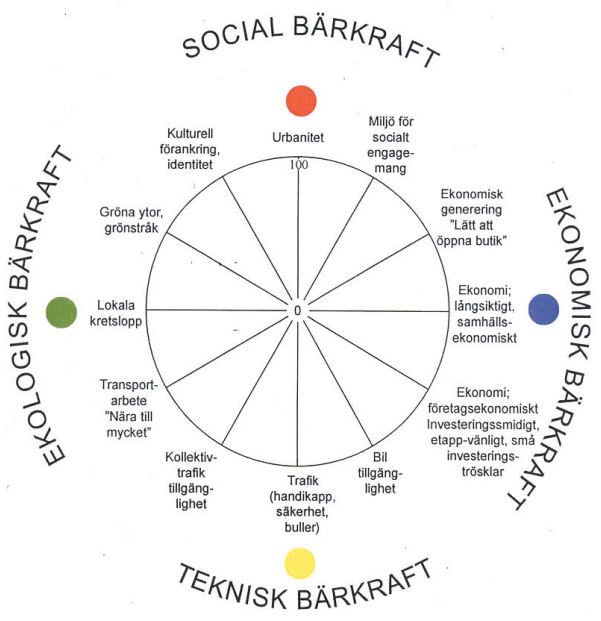

Figure 1 A sustainable assessment map constructed by Thorbjörn Einarsson at Arken Arkitekter AB, Sweden. Different quality aspects are rated from 0-100 and should be marked in the diagram. Aspects covered are for instance: accessibility to public transport, local recycling, green areas, cultural identity. All the ratings in this example are made by subjective evaluations. This must not be the case at all. Quantifiable key factors and indicators could be represented along with qualitative evaluations.

3.4.1 The sustainable assessment maps (SAMS). It is always difficult to compare apples and pears, and this is what we are trying to do when we compare the complicated concept of sustainability. Social, economic and ecological aspects can coexist in the holistic image of the sustainable assessment map. Hard, measurable facts can be presented side by side with subjective evaluations. The purpose of SAMs is to allow the incorporation of dimensions with which there would otherwise be valuation problems into a single model (by allowing non-equivalent scales) to make the decision-making process more accessible, to assist in the clarification of assumptions and positions (Clayton and Radcliffe, 1996).

This is a tricky business and must be carried out with the utmost care. The assessment map manages to combine a lot of different facts into one image that can show a tendency or a profile. By changing different ratios or qualities other things might be influenced as well and this is possible to show with this method. Different shaped maps show different pro and cons. And this is probably as far as it's possible to get with a simple image or measurement.

Here lots of different scores are illustrated in the form of a wind-rose, which indicates a tendency, rather than rating the different projects. This is a method where key factors and indicators can be of great use, because the map-method never gives the message "this is the truth". The map shows an evaluation where a key factor or an indicator can have influenced the result, always combined with a qualitative judgement.

The method is complicated to use since you have to handle a great deal of information and draw conclusions concerning quality when you draw the map. The map gives the viewer a quick glimpse of the situation and maybe that is just the thing you need to inform politicians and non-experts. At least they will realise the complexity of the subject, since the map looks somewhat chaotic.

3.4.2 Benchmarking. The benchmarking method is defined as a search for the best working methods that will lead to the superior achievements (Zinkernagel, 2001). This means that an organisation compares working methods with another organisation in order to get ideas for improvements within the own organisation. It's a learning process where an organisation can improve process, results or strategy. There are no rules for benchmarking and literature suggests many different ways to carry it through. But you have to plan the benchmarking, select areas to compare, choose partners, choose a method to collect data, analysis, compare quality etc. Last of all you have to choose a way to implement the result of the benchmarking by setting new goals, develop plans and measures and follow up activities (Zinkernagel, 2001).

Benchmarking can be almost anything: a meeting between individuals who compare their working methods or a big project carried out over a series of years with strict plans and method. Nevertheless the method allows a combination between quantifiable aspects and qualitative. The key factors and indicators can be supplemented by a deep analysis and a complex set of figures and facts can be compared and balanced in a process that allows discussion and considerations.

4. CONCLUSION

Key factors and indicators can be useful tools for comparisons between different sustainable building projects, but they must be used with common sense. They hardly tell anything about quality and this is a problem when decision-makers get the impression that they actually do.

There lays a big responsibility on anyone working with these tools not to jump at conclusions and try to make them look like they represent more than they actually do. Three chosen examples show how misleading the use of factors and indicators could be.

A combination of qualitative methods and quantifiable ones is recommended. This can be handled in different ways, the sustainable assessment map is a method recommended in this paper, as is benchmarking processes where SAMs can be used as a tool.

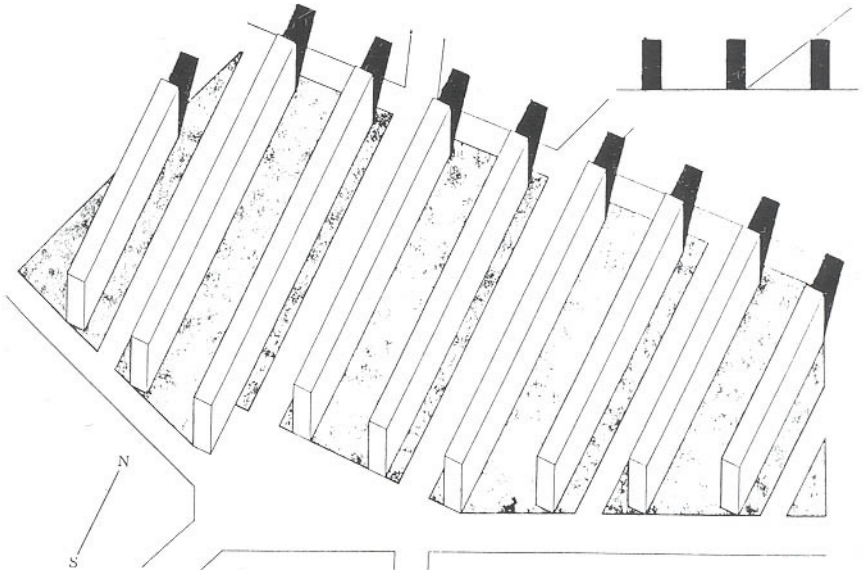

Figure 2 If the solar gain should be the only quality considered when planning a residential area this would be the optimal plan. An excellent key factor never tells the whole story by itself. Other quality discussions are needed as a complement. Illustration from 1928 by architect Uno Åhrén, who like other functionalists based his arguments on key factors.

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Mainstreaming Integrated Design: A Real-World Energy Performance Analysis Approach

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1. INTRODUCTION

Although integrated design has grown in popularity among some building designers who want to produce energy-efficient buildings, a vast majority of designs do not follow the process. One reason for the slow uptake of integrated design may be attributed to the industry's reluctance to deviate from the "way designs have always been done." Another reason is that traditional, integrated design approaches typically involve a staged analysis with several meetings involving the design team. Therefore, there is the perception that the approach is too expensive and that it will slow the design process.

To help address the latter concerns, we collaborated with British Columbia Hydro to help develop and deliver a Design Assistance process. The Design Assistance program's goal is to foster design team interaction while producing a cost-effective, energy-efficient building design. One of the more interesting aspects of the program is that it is not necessarily targeted toward environmentally focused design teams that would have already produced energy efficient buildings. Instead, many of the projects have involved relatively standard-practice designs with typical design teams. In other words, the building designs have not been showcase projects, but instead, ones situated in the realities of everyday design constraints and budgetary limitations. Even with these obstacles, the dozens of projects that have been completed to date illustrate how energy can be saved cost effectively for nearly any new building design situation. This paper discusses the Design Assistance approach to integrated design, presents case studies of buildings that have gone through the program, and discusses key elements to success.

2. THE DESIGN ASSISTANCE MODEL

The Design Assistance process attempts to bring energy optimization to a wide range of building types and clients: from airports to primary schools, from environmentally driven design teams to economically driven owners. The ideal stage for Design Assistance involvement is when a building design is in the schematic design phase. At that point, changes to the design can be made more cost effectively (Montross and Fraser 1988), and the design team is more open to exploring new ideas. However, projects have gone through the program as late as the design development phase and as early as the conceptual design phase.

From the energy performance perspective, the involvement of an energy analyst is a key component of the program—as it is with most integrated design projects. Another key component of the process is the Energy Performance Workshop, which is somewhat unique to the Design Assistance process.

2.1 The Role of the Energy Analyst

At the onset of a Design Assistance project, the energy analyst gathers information about the building design, primarily from blueprints, the architect and the mechanical engineer. This usually involves a short meeting with the architect and engineer. The purpose of the meeting is not only to collect data, but also to ascertain team preferences and receptivity to exploring various opportunities. The brief meeting also helps the analyst understand the design team's circumstances (e.g., cost constraints, technology biases, etc.), and it fosters a spirit of team cooperation.

At this time, the analyst also discusses establishing an energy savings target. For most buildings in the Design Assistance program, an initial energy target has been identified at achieving at least 25% better energy performance than prescribed by Canada's Model National Energy Code for Buildings. At this savings level, the building design would qualify for a financial incentive from the Canadian federal government. Other energy targets have included qualification for special environmental designations, such as Canada's C-2000 designation (50% savings below the energy code), or a point rating level from the U.S. Leadership in Energy and Environmental Design (LEED™) program.

The next step is for the analyst to construct DOE2[1] models to simulate anticipated energy use in the building. The models may represent various scenarios, depending on the project. Typically, the models will represent (1) the proposed design, (2) the proposed design with different heating, ventilation and air conditioning (HVAC) systems, and (3) a reference case model that represents the energy target comparison model, such as a building that meets the national energy code. In short, the analyst must ensure that the models can sufficiently represent most alternative design options the team wants to explore. Additionally, the analyst often prepares additional cases, based on his/her experience, that capture different energy-efficient approaches to provide the design team with other possible alternatives.

An important challenge for the energy analyst is preparing energy simulation models that are accurate but not overly complex. The models need to be detailed enough to provide a satisfactory results on design strategies. However, a balance must be maintained so that the analysis process is cost effective and produces timely results. For instance, in most cases, the full spatial geometry rarely needs to be described since the impact of sizing and positioning every single building surface is typically very small (Jones and Hepting, 2001).

2.2 The Energy Performance Workshop

After the models have been completed, the design team meets for an Energy Performance Workshop. Rather than having repeated, expensive meetings with the design team, the Design Assistance program explores a majority of the design options during a half-day workshop. Because of the condensed format, it is imperative that design team members, particularly the energy analyst, come prepared to explore many different possible strategies. Like most integrated design meetings, the workshop involves key members of the design team, the owner, a cost consultant, and the energy analyst. Unique to the Energy Performance Workshops, however, the analyst performs simulation *during* the workshop. By analyzing energy savings from various technologies in a workshop setting, the team is able to quantify cross-discipline measures (e.g., savings from shell measures may reduce mehcanical

[1] DOE2 is a building energy performance simulation software package, developed by Lawrence Berkeley Laboratories, which is widely used by energy analysts in North America.

equipment sizing needs, as well as the energy cost). As a result, the design teams work as a cohesive unit to make sound, economic decisions about the design.

As an "impartial" party, the energy analyst informs the design team about the energy use implications of their options and lets them make their own decisions. This fosters creativity on the part of the design team as they work to cost effectively reach their energy target. The energy analyst's primary role is to provide information about how energy performance is affected by proposed design strategies. It is common for the analyst to dispel misperceptions about strategies that are thought to be energy efficient but actually yield small energy savings. On the other hand, other measures often ignored might prove to have significant, cost-effective savings (Henderson et al. 2001). While the analyst can provide suggestions, generally most design teams already have good ideas that need to be analyzed. In those cases, the energy analyst simply provides information that helps the team to make better, informed decisions.

Since budgets are nearly always limited and cost optimization is important, it is crucial that the team has accurate cost information for the various measures (both capital and operation and maintenance costs). Oftentimes quantity surveyors provide this information. With accurate costing information, the team can decide which measures to include if they must make trade-offs among measures to stay within project budgets. For instance, a budget allocation for high levels of roof insulation might be better spent on a heat reclaim system because it would save more energy much more cost effectively. The team continues to explore the cost and energy-use implications of various measures until they reach (or usually exceed) their energy target. Because all key design team members are present, the team will usually make changes to the design during the course of the workshop.

As with most integrated design meetings, the Energy Performance Workshop provides an excellent forum for design team members to collectively discuss design issues—even ones that do not affect energy performance. Providing for dynamic energy performance feedback engages everyone and focuses the team on a goal which can be estimated instantly. With the timely analysis feedback, combined with a realistic energy performance goal, the team interaction and involvement improves the design's energy performance.

2.2 After the Workshop

While the Design Assistance process does not generally involve multiple integrated design meetings, its participation does not end upon completion of the Energy Performance Workshop. After the workshop, the analyst reviews all results from the meeting to make sure there are no errors. The analyst is also available, upon request, to review the energy use and cost implications of any additional changes to the design. Oftentimes, the analyst also performs follow-up analysis on more complex strategies which could only be approximated in the workshop.

Occasionally, significant changes have warranted that the design team meets again for a second workshop. Generally, we have found that the level of teamwork and cooperation achieved during the workshop continues after the workshop. More importantly, individual team members learn the value of the integrated design process and most have followed that model on future projects.

3. RESULTS

We have applied the Design Assistance process to dozens of projects, ranging in size from a 1,100 m^2 correctional facility to a 55,000 m^2 hospital. In addition to these building types, projects have included offices, schools (primary through college), laboratories, airports, workshops, extended care facilities, retail, high-rise multifamily facilities, hotels, and a firehall. Clients have been in both the public and private sector, from "green-minded" city planners to capital cost constrained developers. Nearly all of the buildings have qualified for Canada's Commercial Building Incentive Program (http://cbip.nrcan.gc.ca/cbip.htm) and many of the projects recently have aimed for achieving LEED™ certification.

Not including the initial pilot projects, we have conducted Design Assistance analysis on nearly 40 buildings, representing roughly 500,000 m^2 of floor area. Approximately 75% of these projects, representing over 380,000 m^2, were under BC Hydro's program. Overall evaluation results for this project set identified savings of 116,000 GJ and $850,000 in energy costs, as compared to pre-workshop baselines. In comparison to the Canadian code, the savings amount to over 160,000 GJ and nearly $4,000,000 (indicating that typical construction is better than the Code in British Columbia). The opportunities identified during the Design Assistance process have been quite cost effective, with an average payback of 1.6 years. Roughly 20% of the projects have experienced an ideal outcome of reducing both energy and capital construction costs, while attaining a maximum government incentive.

As a demonstration of the different range of projects, we present some case studies of projects that have gone through the Design Assistance program.

3.1 Community College in Northwest British Columbia

The process followed for a 4100 m^2 college facility sited in Prince Rupert, British Columbia represents one of the best examples of applying the Design Assistance approach. With a mandate from the British Columbia government to follow green design practices, the design team had interest and motivation to create an energy efficient building. Hence, the designers had many innovative ideas that they wished to explore during the first conceptual design workshop.

During the conceptual design phase, we provided cursory feedback on the relative energy performance of various design cases. This gave the design team a better understanding of where the largest opportunities lay for saving energy, and they learned that measures they perceived to be very significant actually paled in comparison to others. For instance, prior to the first workshop, the team identified full natural ventilation as an energy saving measure without realizing the constraint it would impose on heat recovery strategies. Focusing instead on exhaust heat reclaim and relief air transfer approaches not only saved much more energy, but it also significantly reduced the size (and cost) of the heating equipment.

From analysis provided during the workshop and a brief follow-up integrated design session, the team concentrated on opportunities that saved energy from heating outdoor air. They accomplished this by centralizing the air systems, implementing displacement ventilation strategies, reusing relief air for shops, and providing for highly effective heat reclaim. They did not remove natural ventilation entirely from the design but instead redirected it to a few computer zones to eliminate the need for mechanical space cooling.

The design's energy performance was revisited during the schematic design and design development phases to further optimize opportunities. With budget constraints apparent,

measures that were not cost-effective were removed so that others may be kept. For instance, the team reduced the roof insulation and specified a less efficient secondary boiler in order to fully maintain the highly effective heat reclaim system. The end result was a design that was shown to save approximately 58% in energy use in comparison to a Code reference building, qualifying it for a $70,000 government incentive. This was accomplished with little or no increase in the capital budget.

3.2 High-Tech Office Building in Vancouver

While the Prince Rupert project represented a nearly ideal application of the Design Assistance approach, a much more typical application of the process was exemplified in the design of a high-rise, 13,900 m^2 office building located in Vancouver, British Columbia. While the owner was interested in energy efficiency, his primary concern was producing desirable, leasable space without increasing the building's capital cost. This produced a more typical situation where the energy performance of the design was visited during the schematic design phase through a single application an Energy Performance Workshop.

One of the most significant results of the workshop was a complete redesign of the HVAC system. By performing life-cycle economic analysis of various systems, the design was switched from a floor-by-floor variable air volume system to a fan coil system. This not only increased energy efficiency, but it also increased the amount of leasable space in the building. Additionally, it was shown that electric heat would be more cost-effective than natural gas heat, particularly when the heating loads were reduced by using better windows and heat reclaim. The final outcome was a design that saved up to $20,000 per year in energy costs and $5,000 in capital costs in comparison to the pre-workshop baseline. Also, the design saved 28% compared to Code[2], qualifying it for an $80,000 government incentive.

3.3 Laboratory Building in Prince George

The Design Assistance process, with the use of a single integrated workshop, was applied to a 5,100 m^2 university laboratory facility located in the relatively cold climate of northeastern British Columbia. The main impetus for following the process came from the lead mechanical designer, who had applied the Design Assistance process to other projects. Hence, we worked most closely with the mechanical designer, who facilitated the process and essentially directed the workshop.

Probably one of the most significant aspects of the workshop was the identification of nearly $18,000 in annual utility savings at a *capital cost reduction* of about $59,000. Much of the savings in energy and costs resulted from the mechanical and architectural designers communicating about the repositioning of the mechanical room to allow for heat reclaim. It turned out that relocating the mechanical room resulted in a significant capital cost reduction that more than offset the increased cost of the heat reclaim system. Energy analysis was provided upon request as the design proceeded, resulting in a building that saved over 40% in energy as compared to Code, qualifying it for a $65,000 government incentive.

4. CONCLUSION

A wide variety of projects have gone through the Design Assistance approach to integrated design. To date, nearly 40 projects have been evaluated, ranging from schools to airports. Every team dynamic is different, bringing different levels of innovation and commitment to

[2] It is interesting to note that the Canadian Code is more stringent for electrically heated buildings, making the savings appear relatively low compared to typical gas-heated buildings.

energy savings. Nonetheless, we have found commonality in the elements that make a project (and an Energy Performance Workshop) a success:

- Willingness of design team to explore new ideas. If the design team members, particularly the owner and mechanical engineer, are not open to evaluating a host of different strategies, they will not achieve an energy- and cost-optimized building.
- Assembling key design team members to work together. As Hayter et al. (1988) also observe, this is an important component of any integrated design. All components of a building affect energy use, so it is important that the design team work together to address the building as a whole.
- Establishing an energy target. This is a critical element because the target presents both a goal and a challenge to the team. The more aggressive the target, the more creatively the team has to work to meet the goal.
- Involvement of an energy analyst. The energy analyst should be an unbiased source that provides real numbers for energy saving technologies. Teams oftentimes have incorrect, preconceived ideas about which measures are energy efficient. The analyst helps educate them and focus their attention on the measures with the greatest energy saving potential (Case and Wingerdon 1988).
- Involvement of a cost consultant during the workshop. This role is an important complement to the energy analyst. While the analyst provides energy use and cost information, a cost consultant can help the team evaluate the life cycle cost of various measures, providing a more complete representation for economic decisions.
- Live analysis. By bringing the energy models into the workshop, the design team can receive timely answers to their questions about the implications of various measures. They therefore are able to make immediate design decisions based on energy and cost information. This helps eliminate the need for several, separate meetings.

While many of the components of the Design Assistance program are part of any successful integrated design process, the concentrated workshop, the live modelling and the focus on budget constraints can help lower the costs of the process and make it more accessible to a wider audience.

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A Green Neighborhood in Yavne, Israel

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A green neighborhood is one that is planned and constructed with an emphasis on a range of environmental components. The need for a planned green neighborhood in Israel is seen in the day-to-day problems caused by high-density development, the intensive use of infrastructure and the desire to raise standards of living while still reducing the cost of homes and maintenance. The solution to environmental problems experienced in residential areas should not be to treat the problems as they arise, but to apply preventative forward thinking of the planning stage.

One of Israel's first green neighborhoods has been planned for the town of Yavne, situated in Israel's southern coastal plain in what is one of the world's most densely populated areas. The local climate is Mediterranean, consisting of two main seasons: a hot dry summer, and a humid temperate winter. As in the rest of the country, this region suffers from a grave lack of freshwater due to low precipitation and high demand.

During the early stages of planning the neighborhood as a green neighborhood, attention was given to elements that required integration into planning, as well as to means of supervision and enforcement that would ensure the smooth integration of these elements into the planning process.

Noise prevention in residential buildings and open spaces

One aim of green residential areas should be to provide a quieter residential environment. This approach will encourage a trend of migration to the city, thereby reducing the need for "dormitory towns" that take up wide areas of open space and encourage commuting. A quiet environment removes the need for noise prevention measures, such as reduced number of windows and window size, and thereby reduces the demand for air ventilation and air conditioning systems that require a lot of energy.

In planning the green neighborhood, attention was given to sources of noise within the area including outdoor play areas, internal roads, mechanical installations and commercial establishments; and sources of noise outside the area, including arterial roads and nearby noise-producing operations.

Preventing noise pollution in noise-sensitive areas can be achieved through:

- acoustic planning of internal lay-out residential units in relation to local sources of noise (such as distancing bedrooms from noisy roads and careful location of mechanical installations such as air-conditioning units etc.);
- functional and acoustic planning of public and open spaces that could potentially produce high levels of noise;
- planning the location of different uses within the grounds of public buildings, and setting a wide buffer of open land around these buildings to reduce noise pollution; and
- the use of acoustic measures in the building envelope, primarily through compliance with the acoustic standards of the Israel Standards Institute.

While planning the neighborhood, it was decided that all acoustic standards, whether obligatory or for guidance only, would be considered obligatory in this case. These standards refer to the acoustic insulation of residential buildings (common walls, ceilings, and floors; entrance halls; noise from elevators); prevention of noise emanating from water supply units, drains and plumbing systems; and the insulation of buildings and their internal areas from airborne noise.

Drainage of runoff from roofs and paths into groundwater

Due to Israel's water deficit, as well as drainage problems caused by urban development, it is vital to use runoff water to the full. This water, which is of high quality, is carried to permeation layers underground in order to replenish groundwater. Due to the nature of the local climate, in which precipitation falls only in winter, there is no reason to store the water for irrigation.

The transfer of runoff underground has a number of advantages, including a significant increase in the amount of rainwater that moves underground, and thus improved replenishment of groundwater; an improvement in the quality of water moving underground as a result of the shorter path taken by the runoff; a reduced risk of flooding due to a significant reduction in the amount of runoff, and a reduction in the cost of repairs to urban drainage systems.

The physical solutions for the transfer of runoff that have been planned for Yavne include the allocation of flood and drainage areas in gardens and open spaces, primarily neighborhood parks; and the use of paving that allows water permeation.

Wastewater recycling for irrigation

The serious deficit of freshwater in Israel also demands the use of alternative water sources where possible. This is primarily achieved through the irrigation of open spaces with "gray" water that today are watered using freshwater.

Following treatment, sewage and turbid water can provide an effective source of water in sufficient quantity for irrigation of open and public spaces in the neighborhood.

In order to recycle water for irrigation, a water treatment facility to purify the water up to the tertiary level is needed. In addition, the irrigation system must be buried or concealed according to Israeli Ministry of Health requirements in order to prevent the water being used for other purposes such as drinking. In addition, treated turbid water can only be used to irrigate vegetation that is not sensitive to the high levels of boron found within it.

Vegetation
Public open spaces in the neighborhood will use local plants that requires little water; are adapted to irrigation using treated water (i.e. water with a high boron content); and are non-allergenic.

The irrigation systems will use water-saving devices such as drip irrigation. Ground cover will be maximized through pruning, or any other method that will reduce evaporation.

Routes for pedestrians and cyclists
The rise in the number of vehicles has led to congestion on urban and neighborhood roads. This causes environmental and safety problems at the urban and neighborhood level for both pedestrians and cyclists. The problem of congestion in Israel is due in part to an inefficient public transport system, an increase in the standard of living and preference for use of private cars, and inappropriate and insufficient planning of routes with regard to pedestrians and cyclists.

The pedestrian and cycling paths in the neighborhood in Yavne will allow access to public institutions, open spaces and adjoining neighborhoods, with an emphasis on creating a user-friendly system. In this regard, the following issues were emphasized:

- the integration of cycling infrastructure into the infrastructure for motorized vehicles (planning bicycle paths as an integral part of planned major routes; connectivity between bicycle paths and transport hubs, including bicycle parking next to bus stops);
- the siting of public and commercial services as a function of bicycle journey distances;
- waiting areas for bicycles at traffic lights in front of vehicles;
- signs, directions and parking for bicycles.
- Separation of bicycle paths from roads, as much as possible.

Optimal land use planning
Optimal utilization of land is an important issue the world over. In Israel it has added importance due to the lack of available land resources in relation to the current and forecasted rates of development. One of the central problems facing the Israeli planning system is the lack of open space, and related building density which is one of the highest in the world. In these circumstances, the optimal use of land, including utilization of underground areas, is a high priority.

This scarce resource can be utilized more efficiently by reducing the area of built-up land. This approach creates improved environmental conditions, such as greater amounts of open space for public use, and larger spaces between buildings.

Land use in the neighborhood plans was optimized primarily through the use of underground areas for functions that do not require daylight or natural ventilation, such as mechanical installations, storage and parking. The land freed up from development as a result was set aside for public open spaces and gardens.

Waste collection and recycling
The most common waste collection system in Israel for residential buildings consists of communal garbage bins that are collected by the municipality. For the green neighborhood in

Yavne there are plans for a pneumatic central waste disposal system. Such a system removes the need for garbage collection vehicles, and their related environmental problems; facilitates compression of garbage near the source, thereby reducing its volume; and encourages the separation of garbage at source through simple sorting methods.

The pneumatic system will be constructed by the developer, in parallel with the rest of the neighborhood-engineering infrastructure.

The system will include sorting mechanisms that allow garbage to be separated at source into both dry and wet waste.

In addition, as Israeli law requires local authorities to recycle 25% of all landfilled waste, means of increasing recycling from commercial establishments have also been included. Commercial areas will contain recycling bins in order to allow separation at source into categories such as paper, cardboard, glass and plastic.

Climate-sensitive construction

During the planning stages, emphasis was put on the need for thermal comfort in sidewalks and buildings.

Thermal comfort in sidewalks is influenced by local wind conditions, shading and the exposure of pavements to sunlight.

Local wind conditions are influenced by the orientation of roads and buildings in relation to prevailing winds, the height and concentration of buildings, and temperature differences produced by the heat-island phenomenon. These factors can lead to a reduction in wind speed in built-up areas, and even to confined areas lacking in ventilation that contribute to air pollution.

On the other hand, the creation of overly strong winds next to high buildings is also a well-known phenomenon, caused by the aerodynamic effect of high-speed winds being forced downwards to street level. This phenomenon produces difficult environmental conditions that prevent regular human activity around such buildings and in adjacent open areas such as parks, paths and roads.

The exposure of pavements to the sun is influenced by the width and orientation of the roads, and by the location and height of nearby buildings.

In order to reduce shading and wind speeds in the winter months, and to allow natural ventilation in the summer, the location of buildings and road orientation in the plan were determined according to local climatic conditions. To this end, a preliminary assessment was made of wind direction and frequency, and of problematic areas of strong winds. This information was then used to determine the orientation of the neighborhood's roads. Given the Israeli climate, shading of open spaces and paths will be needed during the summer months. Means of creating shading include the use of deciduous vegetation that allows maximum exposure to sunlight in the winter and shading of open spaces in the summer.

In order to create thermal comfort in the buildings, all the residential units will be built in accordance with Israeli standards – both obligatory and voluntary – for thermal insulation of buildings and windows.

Use of solar energy
Under the Israeli Planning and Building Law, residential buildings of up to 8 stories must hold solar panels for water heating. In the neighborhood in Yavne, no guidelines beyond the extent of the current law will be set, due to the already high cost of existing solar panel systems.

Prevention of electromagnetic radiation
The rapid increase in the use of cellular phones has caused a growing demand for cellular phone masts or antennae. This rapid rate of development, together with a lack of comprehensive planning, has caused problems such as illegal antennae, little coordination between the different phone companies, and antennae located too close to sensitive land areas. In the neighborhood in Yavne, strict criteria have been set for the location of antennae.

For example, minimum distance has been set between cellular phone masts and residential areas or public institutions. There is also a prohibition on erecting antennae in the grounds of educational institutions or children's play areas.

In order to prevent electromagnetic radiation from electricity supply units, transformers will not be allowed in educational institutions and children's play areas. They may be housed in the basements of buildings, and in underground facilities beneath public open spaces.

THE PLANNING SYSTEM
The multi-disciplinary issues involved in green building in general, and the green neighborhood in particular, are in the early stages of development in Israel, and are being tackled in many different fields. These issues require a complex approach, encompassing professionals working in a range of disciplines.

Green building requires cooperation between planners, architects, engineers, developers, consultants and experts in the relevant fields of construction, as well as in the environmental fields of recycling, pollution prevention, waste conservation, waste management, noise prevention, climatic conditions and general environmental comfort.

The planning of the green neighborhood was carried out in conjunction with the project's architect, the mayor, the municipal engineer, the developers' representatives, and a group of professional consultants dealing with environment, infrastructure, water and waste issues.

During the planning process, the importance of integrating the 'green' elements into the preliminary planning stages became clear, as at these stages it is still possible to influence the basic guidelines of the plan, such as the orientation of roads and buildings, and the allocation of land for neighborhood-wide infrastructure.

It is also important to “anchor” these green elements in the whole process, from draft plans and urban building guidelines, through to the later planning stages and tenders for construction.

The biggest obstacle to planning a green neighborhood comes from the developers involved in the planning process and the plan’s implementation. Green building does in part incur greater capital costs due to the use of advanced and more expensive technologies and materials. These costs fall mainly on the project developers and on the local authority of the neighborhood area. Meanwhile, those who benefit most from this method of building are the residents who are fortunate enough to live in a better quality environment, and in a building where the costs of heating and cooling will be lower due to the investment in insulation and adaptation to the local climate.

Green building is considered to be of higher quality, and is in demand in the Israeli market. The perception of green neighborhoods as prestigious areas causes many local authorities to encourage such projects, in the hope of attracting a community with higher socioeconomic standards, who will also be willing to pay more in order to live in such an area. That notwithstanding, the idea of a green neighborhood is still new to Israel, and the integration of new building elements that have not been tried elsewhere is treated with skepticism by authorities and developers.

SUPERVISION OF THE CONSTRUCTION PROCESS

Due to the strict standards applied to every aspect of construction in a green neighborhood, close supervision is required at every stage.

Supervision during construction will be necessary to ensure that every developer involved complies with all the requirements included in the neighborhood’s environmental regulations.

It will therefore be necessary to request interim reports and conduct various tests at different stages of construction. The number of reports and extent of testing will be determined by the municipal engineer to ensure that the building and/or project complies with the requirements of the green building license and is consistently assessed during construction.

The green building approval will have to be obtained from the planning authorities before the buildings are occupied. In order to obtain the approval, the applicant or developer must demonstrate that the plans and their implementation have adhered to the environmental regulations. The application will be evaluated on the basis of environmental and construction documentation.

Criteria for Green Planning and Building in Israel

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Abaut 80% of Israel's residents live un an urban environment. Forecasts suggest that the trend of urbanization will only increase in years to come. In order to raise the quality of life in built-up areas, there is a need for the development of green building components, particularly in areas of high density. Such components must be implemented during the initial stages of planning towns, neighborhoods and the buildings within them.

Accelerated development, and a lack of intensive public involvement, has led to a situation in which most construction in Israel does not take any green factors into account. In order to encourage green planning and building in Israel, the Ministry of the Environment has initiated activity within this field with the aim of defining and eventually institutionalizing criteria for the construction and development of green buildings and neighborhoods.

This paper presents the parameters that were found to be appropriate for inclusion in an Israeli Green Building Scale. The weighting given to these parameters reflects both global and local Israeli priorities for green building. Also presented here is the rationale for developing criteria for a Green neighborhood Scale, and the parameters relevant to that field.

PRINCIPLES IN THE DEVELOPMENT OF ISRAELI CRITERIA

The purpose of the Israeli Scale is to encourage sustainable development, and as such it refers to the following topics: energy, water and waste.

It was found that the best way to implement the Scale would be to increase public awareness and thus encourage demand from the consumer, which would in turn motivate those involved in the construction process – planners, developers and contractors – to integrate green components into their buildings and into the neighborhoods that they plan and build.
In order to raise the necessary interest and demand, additional components that reflect good quality planning can be included in the Scale. Their contribution to sustainable development is not only direct, but also indirect – for example, pleasant acoustic conditions and good air quality. Thus further such parameters relating to interior environmental quality were added to the Scale.

The combination of environmental and quality of life issues comes from a need to integrate variables that benefit the user with those that promote environmental and global goals, in order to

further integrate green planning and building into general policy. As such, criteria that aim for sustainable development should be integrated with economic incentives that embody financial savings and greater environmental comfort, rather than relying solely on ideological, voluntary incentives.

THE GREEN BUILDING SCALE

The Green Building Scale consists of four main assessment categories. Three of these deal with issues that are directly connected to sustainable development and the building's influence on its surrounding environment: energy use; water and sewage; and solid waste. The fourth category assess the building's internal environment.

The Scale assesses the building itself, the land on which it is built and the infrastructure leading to and from the building.

1. Energy Use

Energy use is the most complicated category of all those currently included in green building assessment models.

A reduction in the amount of energy used in the running of a building is one of the most important requirements of a green building, and it contributes directly to a reduction in the amount of greenhouse gases emitted into the atmosphere.

Due to the many variables and considerable lack of accuracy involved in calculating the amount of energy used in producing building materials, transferring them to the site and their use during construction, the Israeli Scale will not include an evaluation of energy used in construction of the building.

The Israeli Scale will meanwhile evaluate methods included in the design to reduce the building's use of fossil fuel-derived energy, using criteria such as: design of different building components (thermal insulation, openings, ventilation, shading, passive solar heating); lighting techniques; the building's climate control (heating and cooling system); and the water heating system.

2. Water and Sewage

This category considers three variables: freshwater use, use of runoff, and the flow of sewage into the urban sewerage system.

Freshwater use – evaluates methods for reducing freshwater use that were included in the building's design.

Utilization of runoff – evaluates elements that facilitate permeation of runoff into the ground from non-polluting surfaces such as roofs, paths etc.

Sewage – evaluates methods that reduce the amount of sanitary sewage produced by the building, via separation of sewage and greywater systems, and/or local sewage treatment systems that allow local use of treated wastewater.

3. Solid Waste

The building's design will be assessed with regard to methods to reduce the amount of domestic waste intended for disposal, through the separation of waste to allow recycling and processing according to basic components. (In Israel, the landfill is still the principal method of domestic waste disposal, even though there is a severe lack of land available for extra landfills.)

4. Internal environmental quality

This category will assess two parameters:

Air quality and ventilation – the design will be assessed with regard to methods that prevent concentrations of air pollutants above acceptable standards; and that provide sufficient natural ventilation in the residential units.

Noise and acoustics – the plans will be assessed with regard to elements to reduce noise produced both within the building and by external sources.

Points and Weighting in the Green Building Scale

The minimum requirement for receiving a green building designation has been set as follows: points must be received for at least one element within each of the Scale's broader categories, and there is a minimum requirement for some of the categories.

In addition, the designation has two grades. The final score will either result in a simple 'green label' (requiring 55 out of the possible 100 points) or a 'green label with distinction' (requiring at least 80 points out of 100).

The table below sets out the point system for the Scale:

Category	Requirement	Points Awarded	Minimum Requirement
Energy	Basic level of energy saving	15	Compliance with requirements of the Energy Code and the Planning & Building Law
	Higher level of energy saving – 3 stars	5	
	Higher level of energy saving – for every extra star	5	
Water and Sewage			
Water	Methods for reducing water use	10	
Drainage	Methods for drainage of runoff from non-polluting surfaces	5	
Sewage	Systems for separating greywater	5	
	A greywater treatment system	5	

Waste	Space allocated for different recycling containers in the residential units *or* other means for separating waste for recycling, as outlined	5	
	Methods for reducing the amount of waste from construction, and for recycling	5	Evidence of linkages with an authorized landfill for construction waste, or for crushing waste for re-use
Internal environmental quality			
Air Quality and Ventilation	Supply of fresh air from a clean source, as outlined	5	
	Ventilation systems for kitchens and bathrooms	5	
	Means of preventing exposure to radon gas in ground level apartments	5	Compliance with standard no. 4175 – passive techniques for checking radon gas concentrations: buildings
Noise and Acoustics	Methods for reducing noise in the room envelope, as outlined	5	
	Acoustic insulation of the building's mechanical systems (air conditioners, pipes, energy systems)	5	Compliance with standard no. 1004/3 – acoustic insulation in residential buildings, and no. 1418 – noise from plumbing systems
	Methods to prevent noise travelling across walls and floors shared by different building sections (rooms, residential units, staircases)	5	Compliance with standard nos. 1004/1 and 1004/2 – acoustic insulation in residential buildings
Assessor's Observations	The assessor is entitled to award extra points based on other factors not included in the Scale	10	
TOTAL		**100 points**	

THE GREEN NEIGHBORHOOD SCALE

A green neighborhood is not simply a collection of individual green buildings, but a whole residential area of higher environmental quality achieved through neighborhood-wide green planning.

A review of green building criteria and indicators in the world reveals that there are no models for green areas such as neighborhoods, industrial zones etc. (This is despite the fact that some of the elements required of a green building and included in indicators for green buildings, are not directly influenced by the planning of the building itself, but rather related to the overall planning of the area in which the building is located). These elements include the infrastructure serving the building; planning of public open spaces; and planning of the building layout to avoid phenomena such as strong winds, shading and urban heat islands. Due to these broader issues, there is a need for a separate indicator for green neighborhoods.

The 'green neighborhood' in this case refers to the public area between buildings. It is assessed according to the parameters outlined below, through examination of a number of professional appendices to the plan (such as drainage and irrigation; transport; climatic planning). These appendices list the techniques that were integrated into the plans in order to transform the area into a green neighborhood.

The Green Neighborhood Scale includes the following parameters:

1. Utilization of water resources

Runoff - This parameter evaluates the methods included in the design to facilitate the drainage of water from non-polluted surfaces, such as roofs and pavements, into groundwater.

Recycled water - This parameter evaluates the design with reference to methods and tools that allow the use of secondary water sources in irrigation of open spaces.

2. Recycling domestic waste

This parameter evaluates methods included in the design for the collection of waste for recycling. Such techniques include recycling containers in buildings for domestic waste; neighborhood containers situated in central places at convenient distances from buildings; and pneumatic waste disposal systems that facilitate separation of waste for recycling within buildings.

3. Bicycle paths

This parameter evaluates the bicycle route system, and its integration of the above issues.
In terms of planning a cycling infrastructure, the following issues must be addressed:

1. Location of cycle routes in the area;
2. The integration of cycling infrastructure into the infrastructure for motorized vehicles
3. The location of public and commercial services as a function of bicycle journey distances;
4. Signs, directions and parking places for bicycles.

4. Climatic planning

The trend of increasingly crowded built-up areas and elevation of the skyline are likely to have a serious detrimental effect on the climatic quality of built-up areas. Nonetheless, controlled planning based on appropriate concepts can prevent this negative impact and can even improve the local climate in such areas. Climatic planning includes two parameters: thermal comfort and solar rights.

Thermal comfort at street level - This parameter evaluates the methods to preserve thermal comfort on streets within the green neighborhood. To this end, the design must demonstrate consideration of natural ventilation of streets and enclosures, prevention of wind disturbance around high buildings, planting of trees and vegetation in open spaces and along streets, creation of shading during summer months and reduced shading of pavements during the winter.

Preservation of solar rights - This parameter evaluates methods for reducing the impact of shading by buildings during the winter on land uses that are sensitive to the presence of sunlight (e.g. public gardens, facades of residential buildings, roofs with solar panels). The evaluation will refer to the following document: "Criteria and standards for solar rights: a literature review and recommendations for Israeli regulation".

5. Acoustics

This parameter evaluates the methods employed to create improved acoustic conditions near sensitive land uses (e.g. residential buildings, public institutions, playgrounds). Such methods include the separation of sensitive and noise-generating land uses, and the construction of noise barriers.

6. Optimal use of land resources

Optimal utilization of land is an important issue the world over. In Israel it has added importance due to the growing lack of available land resources in relation to the current and forecasted rates of development.

This scarce resource can be utilized more efficiently by reducing the total area of built-up land. This approach has environmental benefits, such as greater amounts of open space for public use, and larger spaces between buildings.

This parameter evaluates the methods employed to optimize use of land resources in the area. This evaluation covers the following elements:

- The extent of open spaces and developed land as compared to the entire area/number of residential units/total built-up area.
- The extent of developed underground areas as compared to the entire area/total built-up area.
- The compacting and recycling of low quality urban fabric (infill development).

The next stage of the project will be to set out the point system and weighting of the parameters given here.

wwPrefab buildings 2001 - Sustainable single family houses with extremly low primary energy consumption

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1. INTRODUCTION

The Fraunhofer Institute of Buildings Physics in cooperation with various industrial partners have developed energy concepts for wooden prefabricated dwellings with low energy demands [1]. The results were a low-energy house with heating demand of about 50 kWh/m²a, a ultra-low-energy house with a heating demand of about 30 kWh/m²a and a zero heating energy house. Additionally the ratio of primary energy demand during the manufacture and during the use of the three building types was investigated in order to find out if there are significant changes [2].

2. BUILDINGS AND HVAC-SYSTEMS

The low-energy house and the ultra-low-energy house form a duplex house. The zero heating energy house was manufactured as a stand-alone building. The building components are wooden frames with mineral wool in various widths for the panels. The ultra-low-energy house and the zero heating energy house own a ventilating system with heat recovery. The low-energy house is provided with fresh air by opening the windows. A gas-boiler provides heat for the building and the domestic hot water in the low-energy house. Additionally 4 m² of solar panels are installed at the roof to support the heating of the domestic hot water. In the ultra-low-energy house a condensing boiler with gas as fuel and 12 m² of solar panels covers the heat demand of the building and the domestic hot water. The zero heating energy house uses 40 m² of solar panels for the supply of heating demand and domestic hot water. The seasonal storage is realised by a 20 m³ storage. Radiators are used to distribute the heat. Figure 1 shows photographs of the three houses.



Figure 1 Photographs of the analysed houses. The left picture shows the low-energy house on the lefthand-side and the ultra-low-energy house on the right. The stand-alone building on the right picture is the zero heating energy house.

3. RESULTS OF THE ANALYSIS

The life-cycle of buildings can be divided into manufacture, use, maintenance and demolition. The analysis [2] has looked solely at the parts manufacture and use. All results are related to the usable area defined by to the German regulation code “Wärmeschutzverordnung”. The usable area of the low-energy and the ultra-low-energy houses amounts to 184 m² per house; the zero heating energy house has a size of 180 m².

Figure 2 shows the primary energy demand of the buildings for construction and use during 50 years. The static construction and the building envelope dominate with 90 % of the manufacturing expenses for the low-energy house and about 75 % for the zero heating energy house. The heating system and the solar panels contribute with 5 % at the low-energy house and with 20 % at the zero heating energy house to the primary energy demand. The primary energy demand of the static construction and the building envelope was additionally divided into heat exchanging and non heat exchanging components. The share of primary energy demand caused by non heat exchanging components was surprisingly high with 40 to 50 % of the total demand. Attention has to turned on the interior building components as well. The primary energy demand for the manufacture increased from the low-energy house up to the zero heating energy house, yet the total primary energy demand during 50 years of use declines. The reduces of the heating energy demand are significantly higher than the necessary additional energy during the manufacture.

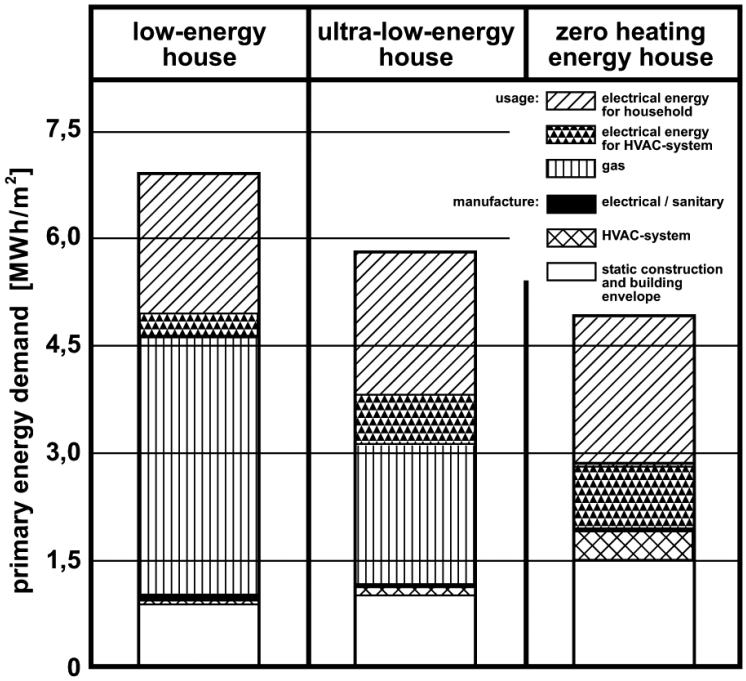

Figure 2 Primary energy demand used for manufacture and use of the buildings related to the usable floor area. The utilisation time is defined to 50 years.

Figure 3 shows the primary energy demand of the three analysed buildings dependent on the utilisation period. Added was a the performance of a building that was designed just according to the German national standard (Wärmeschutzverordnung). This building spends more primary energy demand than all other three buildings after just a few years. The balance of the zero heating energy house is getting positive compared to the regular house after 12 years, compared to the low-energy house after 15 years and compared to the ultra-low-energy

house after 25 years. Therefore the aim should be to build houses with superb insulation and adjusted HVAC-systems.

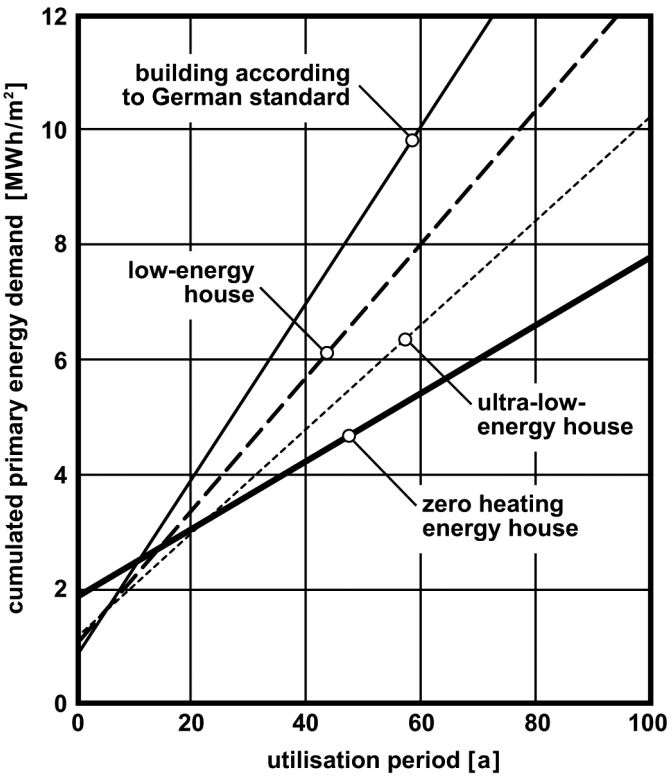

Figure 3 Cumulated primary energy demand of the different building types dependant on the utilisation time.

4. LITERATURE

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Green Aluminium-Sustainable Office Buildings with Aluminium Facade Constructions

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1. INTRODUCTION

Globalisation of the economy in addition to new requirements for humane working conditions lead to new ways of cooperation in the society. This results in totally new demands for the design of working processes, buildings and technologies. Integral concepts, based on synergy and cooperation are searched for. Work with various relations of cooperation becomes a significant feature of modern working organisations. Office buildings shall be a business card of the future-oriented company and a germ cell of individual creativity of the staff at the same time.

From the point of design and construction the future office will have to increase the individual comfort in regard of acoustics, room climate and optics with reduced expenses for maintenance. Nevertheless the trend towards transparency, lightness and naturalness in facades hasn't stopped. Sustainable design concepts for office buildings have to take this development into account.

2. BACKGROUND

Aluminium in building application is perceived as non-ecology minded mainly in the opinion of environmentalists and even sometimes governmental organisations. In fact Aluminium based products are trendsetting regarding energy saving, maximising occupiers comfort and ecology minded design.
Hydro Building Systems/Wicona Bausysteme GmbH, Germany decided to launch a project in order to analyse and define the key indicators (energy saving, maximum comfort, ecology minded design) and develop or improve products for the sustainable use of aluminium in a façade of non-residential buildings.

3. PROJECT DESCRIPTION

The structure of the whole project is defined in two subprojects.
<u>Subproject 1:</u>
Task 1: Stakeholder analysis and workshop

- Start a stakeholder analysis
- address NGOs, opinion leading people and other main player in the market
- organize a workshop with them

Task 2: Design and technical development of two typical office buildings
- development of an office building with significantly reduced energy consumption and embodied energy
- design and engineering of the total concept (façade, building layout, HVAC, lighting, ..)

Task 3: Cooperation and communication of the results and output of task 1 and 2
- open communication towards NGOs
- incorporate NGOs, trendsetting institutes, opinion leading people into this project from the very beginning

Subproject 2:
Task 4: Realisation of an ecology minded office building
Task 5: Communication of results and guidelines of the project in total

3.1. Task 1: Stakeholder Analysis and Workshop

As a main objective for Task 1 open communication towards non governmental organizations (social and environmental NGOs) was aspired. In a first step environmentalist, trade unions, members of administration and regulation authorities have been addressed. A questionnaire, "Office Buildings for Future Generations - Sustainable Solutions with Aluminium Facades" was run. The addressed persons were interviewed on their opinion concerning aluminium in general and on its use in the building industry (i.e. design options, LCA, influence of recycling, ..). Main target was to investigate on the key factors or core indicators from their point of view.

The main arguments against aluminum were the ecological and social disadvantage of bauxite mining and high energy use for primary melting. On the other hand aluminium was confirmed as a excellent material regarding durability and therefore minimizing cost for maintenance, flexible and easy to handle, best design options, good cost-performance ratio, best option for recycling and able to realise high end technical solutions in construction and building products.
The received opinion from technicians didn't vary so much. The statements on ecology from environmentalists was as expected the worst. At the same time there was a lack of information determined among these people about the technical solution which can be realised with building components made of aluminium.

In spring a first workshop with stakeholders took place. Once again bauxite mining was located as the main disadvantage of aluminium. The participants appreciated a high rate of recycling if possible in a closed loop within the building industry. Significantly reduced energy consumption, careful use of resources (energy saving, embodied energy) and maximum comfort (thermal, humidity, air speed, emission, natural daylighting, …) for users turned out to be important for the participants of the workshop.

At the moment in a second step a few NGOs will be integrated in the project via an advisery board in order to reflect the scope and the results of Task 1 and Task 2 continuous.

3.2. Task 2: Design and technical development of two typical office building

The development of guidelines for the energy optimised design of future-oriented office buildings with low energy demands and high comfort levels shall take place with representative designs. Therefore the study started with an analysis of realised office buildings from the last 10 years.

3.2.1 Analysis of innovative office buildings of the past years: 133 office buildings which have been realised in the last 10 years have been evaluated by literature including detailed descriptions of architecture, building envelope areas and heating and ventilation systems. The aim was to find out whether there are characteristic key values and developments in order to identify typical buildings for the study. Figure 1 represents the analysis of the geometrical key values. It shows that the analysed buildings represent a wide spectra. Most part of the buildings are in the range of 10.000 m² gross floor area. Though there is a variation between the buildings, a tendency line can be determined. The identified typical buildings shall be oriented to this tendency line.

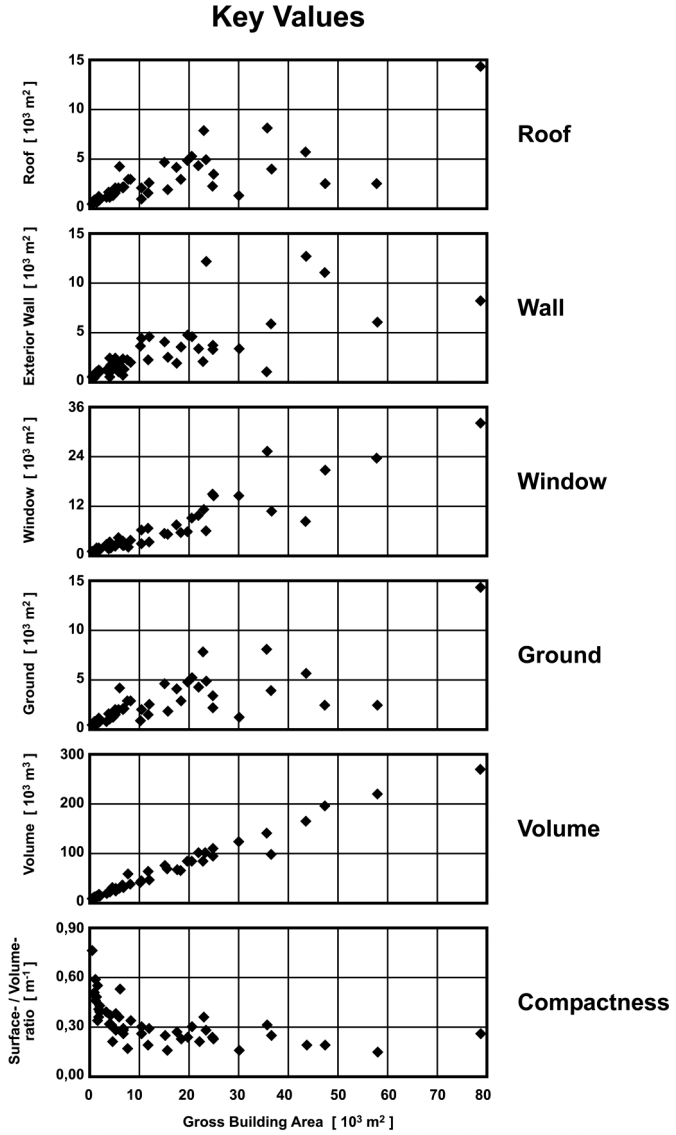


Figure 1 Comparison of geometrical key values of new office buildings in Germany.

3.2.2. Determination of the assessment criteria: The analysis of the impacts on the design, the facade developments and the technology for HVAC-systems of the chosen typical buildings shall be oriented to the following criteria:

- primary energy demand for the construction of the building
- primary energy demand for the occupancy of the building
- heating energy demand
- cooling energy demand
- lighting energy demand
- daylight autonomy
- overheating occurrence

Moreover general statements shall be derived on glare problems, acoustics, natural ventilation, thermal comfort and individually influenceable office climate.

3.2.3. Selection of two representative building types: Two basically different office buildings have been selected out of the analysis of the realised office buildings for conducting further inquiries. The basis for the small office building is provided by 17m (4-storey) high authority center. The building has a gross floor area of 7250 m² and a surface-to-volume ratio of 0,33 m^{-1}. Figure 2 shows the schematic floor plan and a view on the realised building.

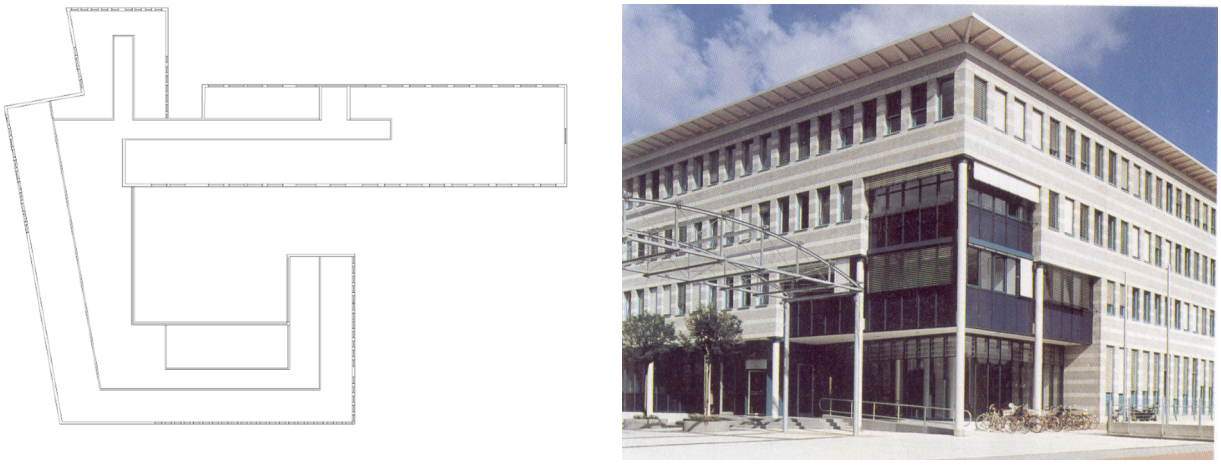


Figure 2 Schematic floor plan of a standard storey of the analysed small office building and view of the realised reference building.

A 125m (33-storey) high administration building represents the tall office building. The building has a gross floor area of 30.200 m² and a surface-to-volume ration of 0,16 m^{-1}. Figure 3 shows the schematic floor plan of the study in comparison to the realised building.



Figure 3 Schematic floor plan of a standard storey of the analysed tall office building and view of the realised reference building.

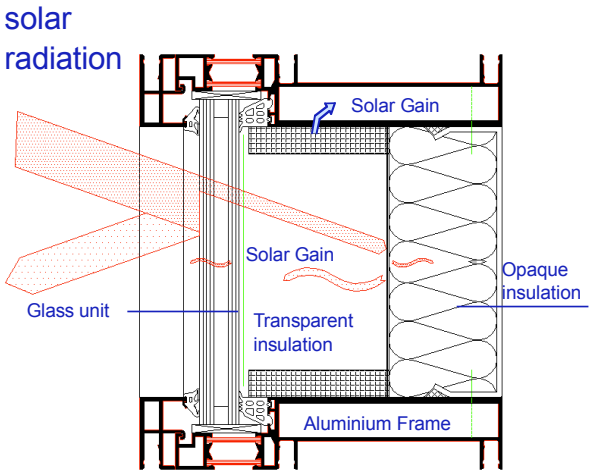
3.2.4. Reference case: As reference case for both typical buildings requirements of the new German regulation code "Energieeinsparverordnung" were taken. The small office building was designed: The façade consists of stick wall system with a window area of about 45 % and insulated panels used as balustrades. 50 % of the windows are fixed. The average heat transmittance coefficient amounts to 0,79 W/m²K.

building part	U-value [W/m²K]
roof	0,30
window (to be opened)	1,56
window (fixed)	1,46
balustrade	0,88
massive wall	0,30
cellar ceiling	0,45
average	0,79

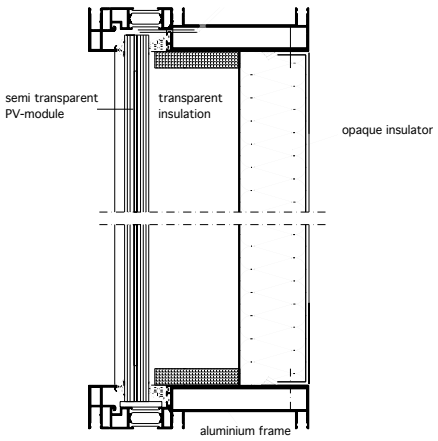
The building has no air condition, is ventilated by opening the windows and heated by radiators, which are supplied by a condensing boiler with gas as fuel. The heating energy demand of the building amounts to 50 kWh/m²a, the primary energy demand for heating to 55 kWh/m²a. The electric energy demand for lighting is about 25 kWh/m²a respectively 75 kWh/m²a as primary energy. Moreover the building requires additional electrical energy of about 40 kWh/m²a. The total primary energy demand levels to 250 kWh/m² per year. The manufacturing and construction of the building caused about 1200 kWh/m². During 5 years of use the building will spend more energy on the maintenance than required for the whole erection phase.

3.2.5. Analysed variants: It shall be analysed for both typical buildings whether the use of high quality façade technology and intelligent HVAC-systems can decrease substantially the primary energy demand and therefore contribute to the climate protection. In this connection not only the use of the building will be investigated but also the synergy between the erection and the use of the building. The aim is to reduce the primary energy consumption by more than 50 % in comparison to the reference case. For example different façade systems shall be used. Coupled windows, double facades and semi-transparent panels for balustrades shall investigated as well as innovative lighting solution and supporting ventilation.

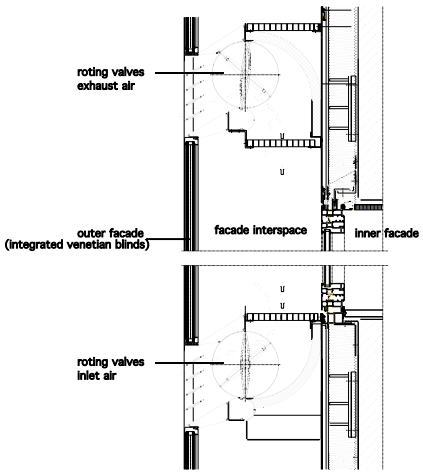
PSW-Passive Solar Wall



Triple-S-Panel



DuoWall 2



Coupled Parallel Opening Double Acting Window

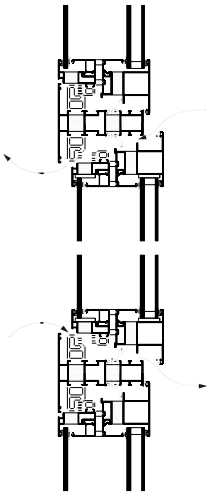


Figure 4 Collection of façade technologies to be analysed in the project.

4. PERSPECTIVE

The study shall be largely finished by the summer of 2002. Therefore actual project results may be presented at the conference.

Energy Saving Facades for Tropical and Subtropical Regions

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1.INTRODUCTION

Nowadays energy is a limited resource. Design and technical improvements for sustainable buildings have to assess this fact. Therefore energy saving turned out to be the most important objective target in sustainable developments for buildings.
In tropical and subtropical regions office buildings spend a great amount of energy to care for a pleasant indoor climate. Mainly electrical energy is used to drive chillers, business machines and artifical lighting of course too.

In this project the investigations were focused on Brazil, in particular the region around Sao Paulo. Brazil has been a well growing country during the last years and consumption of electrical energy is still increasing. 91% of electrical energy is produced by hydro power plants and Brazil is the third biggest producer in the world. Owing to a drought a lack of water occurred in 2000. The government passed a decree that everybody (private and also industrial companies) has to save at least 20% electrical energy on average otherwise high penalty have to be payed.

Hydro Building Systems in cooperation with Hydro Aluminio Acro/Sao Paulo launched the following project. Different facades were analysed due to their potential of energy saving in combination with HVAC and artifical lighting in an office space. The scope of the project is to reduce the energy consumption in total by 30%.

2. OBJECTIVES OF INVESTIGATION

- Improve the design of aluminium façades in tropical and subtropical regions for reducing energy consumption and therefore reduce the energy use of electrical energy for cooling appliances and artifical lighting of these buildings.
- Develop an energy saving facade and communicate guidelines allowing integrated design of HVAC and lighting.
- In addition the situation of local markets in particular cost frame should be met.

3. STATE OF THE ART

Facade:

- In modern building high reflective or body tinted solar protecting glass is common. But almost everywhere used as single glass in combination with internal blinds against glare.
- Shadow boxes in the spandrel area and in front of reinforced concrete
- No thermal insulated aluminium profiles (compared to Europe)
- Insulation is only used for fire protection
- The common architecture prefers buildings with structural sealant glazing design and without external blinds or sunshading devices.

HVAC and lighting

- cooling appliances normally using air based systems with air in-/outlets in the ceiling or in the floor
- centralized systems for HVAC are common
- no systems compareable with Europe (cooled ceiling, activating thermal mass of ceiling, night time cooling, natural ventilation)
- artifical lighting permanent switched on during office occupation

4. ANALYSIS OF COOLING LOAD OF A TYPICAL OFFICE SPACE AND FIRST IMPROVEMENTS

In a first step the cooling load of a common office space in Brazil was calculated. Then different types of a stick wall façade due to glazing, internal blinds, spandrel and U-Values of the frames were considered.

Assumptions:

dimension office rooms: (WxDxH) 5m x 8m x 2.5m
window/wall-ratio: 60/40
orientation of façade: north-west
inside air temperature: 24°C (constant during office occupation)
internal loads (persons, business machines, lighting): 36W/m²
adiabat internal walls
weather data: A typical hot summer day of Sao Paulo was added six times in order to get a period of a critical week.

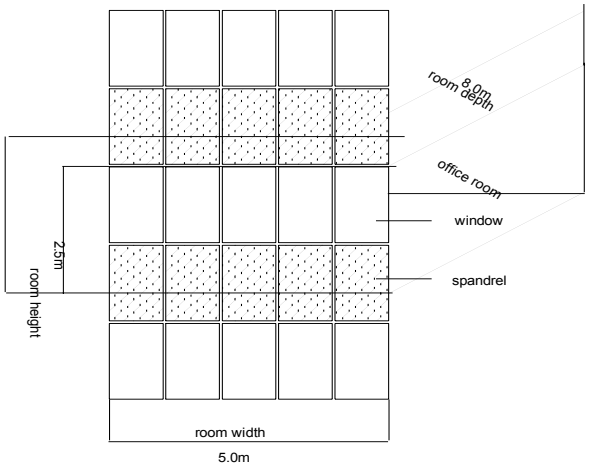

Fig 1: Front view to the stick wall façade and defined office space

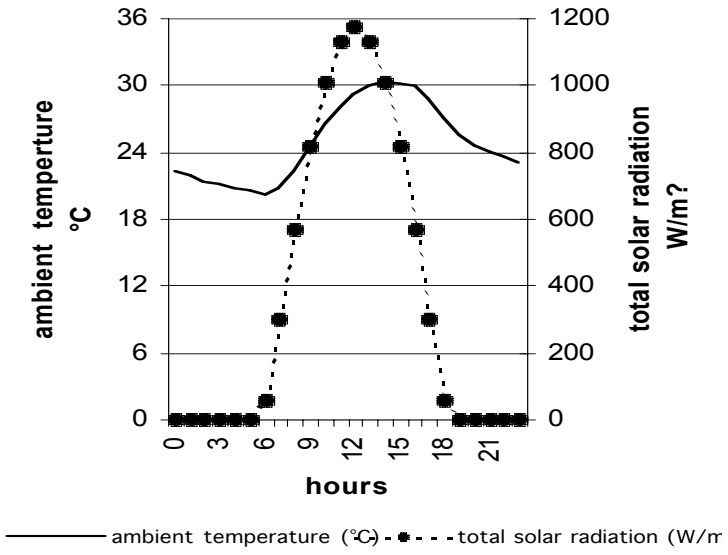

Fig. 2:Typical hot summer day for Sao Paulo (Feb 15)

The results of the first thermal numerical simulation are illustrated in figure 3. In this first step a reduction of the peak cooling demand of 29% was reached by improvements of the façade components.
Heat flow goes mainly through glazing and frame. Insulation in the spandrel area don't have so much influence as expected because of the concrete behind spandrel area. The main influence turned out to be the U-Value of the aluminium frames.

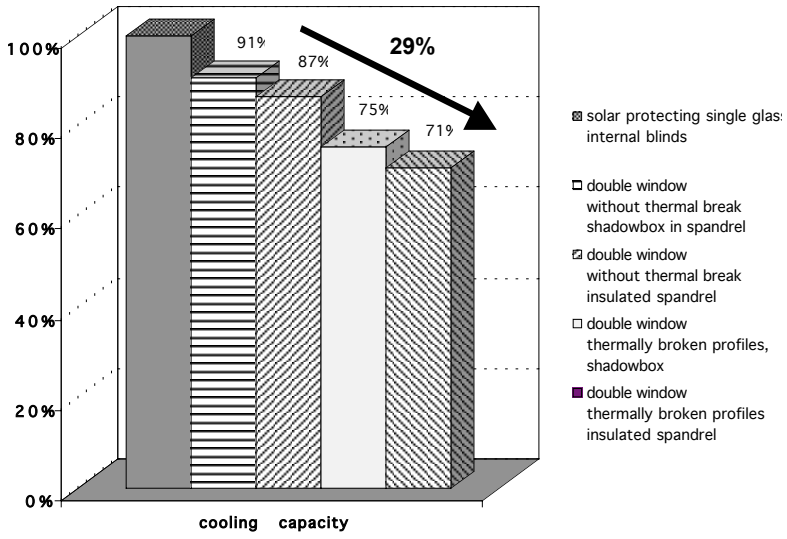

Fig. 3: Improvements step 1, due to cooling load for an average office space for different types of glazing, frames and spandrel

5. EXISTING ENERGY SAVING CAPACITY OF THE FAÇADE ALONE

For more detailed investigations we decided to have a closer look at the performance of the façade and on their components alone. In step 2 we carefully modeled a aluminium facade without an office space behind.

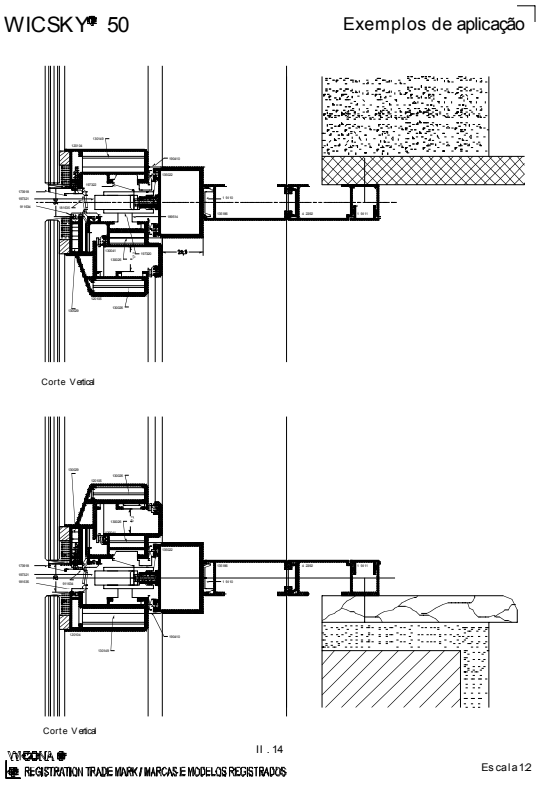

Fig. 4: Vertical section of structural sealant glazing façade, concrete balustrade and shadowbox in the spandrel area

Different versions of glazing/facade systems and aluminium frames have been combined and calculated. In the end results 21 possible system combinations have been investigated. This allows to vary a standard system according to local climate.

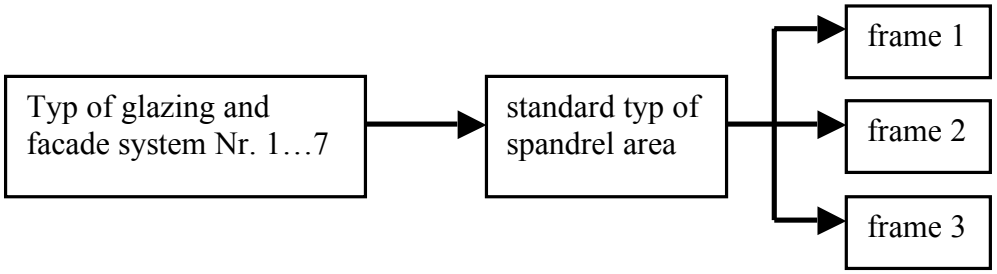

Fig. 5: combination of glazing/façade system, spandrel area and frame

In relation to the results of step1 (s. Fig. 3) influence of glazing/façade system and type of frame occured again. Figure 6 presents a set of combinations and range of possible heat flow reduction.
Compared with a common facade (state of the art) maximum improvements of the peak heat flow from 23% up to 70% are possible. Heat flow over 24 hours can be reduced from 21% up to 66% with the investigated combinations.

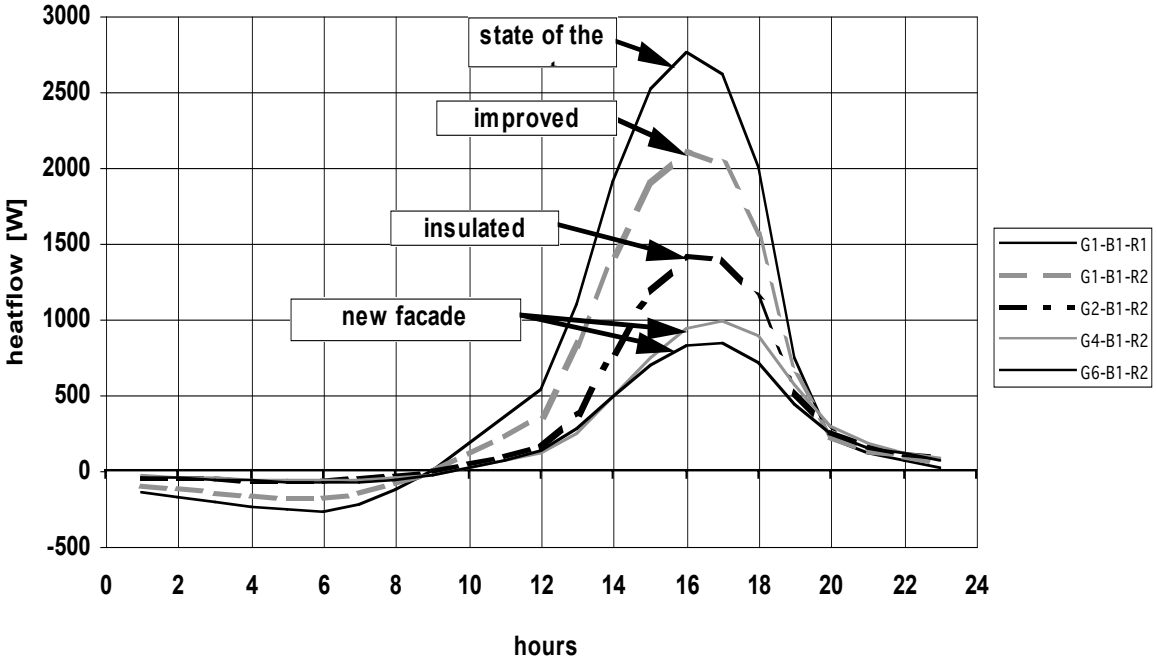

Fig. 6: heat flow through façade – glazing, spandrel area, frame

6. PERSPECTIVE AND FUTURE ACTIVITIES

6.1 Total energy saving potential

6.2 Energy saving potential of daylighting systems

Energy saving potential of daylighting systems integrated in a façade. The expected results will show electrical energy savings as a ratio of dimension for window/daylighting system.

6.2 Calculation of conjunction between façade and innovative HVAC-strategies

Search for chances of natural ventilation and night time cooling.

Until the conference in September all results will be available and be presented.

Climate Change Mitigation & Adaptation Tools for Homes & Offices in New Zealand

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1 INTRODUCTION

Since 1997, BRANZ has researched both the direct and indirect implications of climate change on homes and offices for the building industry in New Zealand. This involved studies into both the technical and social aspects of climate change and resulted in a number of technology transfer activities, e.g. reports, articles, seminars and other presentations. Concurrent with these activities was the need to provide easy-to-use information that demonstrated *practical solutions for individuals* to reduce both personal greenhouse gas emissions in, and to prepare for the impacts of climate change on, their homes and businesses.

Two paper-based publications were developed to achieve this; one focussing on mitigation based on the concept of 'Becoming a Climate-Friendly Citizen', the other focussing on adaptation called 'Coping with Climate Change'. The key objectives were to encourage individuals to think about the connections between their actions and impacts on the climate, and enable people to take action to prepare for the likely impacts. This paper discusses the background of the issue from New Zealand's perspective, describes the development and content of these two tools, along with their future directions.

2 CLIMATE CHANGE AND NEW ZEALAND

The climate is in a constant state of change. We know that Earth's climate has naturally varied over the past thousand years, and for millennia before that, for a variety of reasons (MfE, 1997). Climate change itself is not the concern; it is the current rate of change and the causative factors that are creating threats and opportunities for all communities around the world. Strong evidence from the scientific community is stating that the relatively rapid climate changes observed over the past hundred years are at least in part due to increasing greenhouse gas levels in the atmosphere[1]. Indeed most of the warming observed over the last 50 years is attributable to human activities, in particular, the burning of fossil fuels (IPCC, 2001).

New Zealand is experiencing changes consistent with global warming trends. In the last 50-100 years we have already warmed, on average, 0.7°C, the sea has risen 10-25 cm, and our glaciers are 40% shorter and cover 25% less area. In addition, there have been changes in rainfall averages and extremes, with shorter period rainfall fluctuations due to the counteracting, or reinforcing effects of the El Nino Southern Oscillation, and the Interdecadal

[1] Greenhouse gases include carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, perflurocarbons, and hydroflurocarbons.

Pacific Oscillation. (J. Salinger; cited in Wratt, 2002). Projections for New Zealand to the year 2080 include:

- Changes in average rainfall patterns, with very heavy rain more frequent;
- A 1°C to 2°C temperature increase;
- Fewer frosts;
- Sea level rise of 30-50 cm;
- UV and net solar radiation changes;
- Enhanced westerlies;
- Potentially more tropical cyclones; and
- Snow line rise and glacier shrinkage

(B. Mullan, cited in Wratt, 2002; Camilleri, 2000).

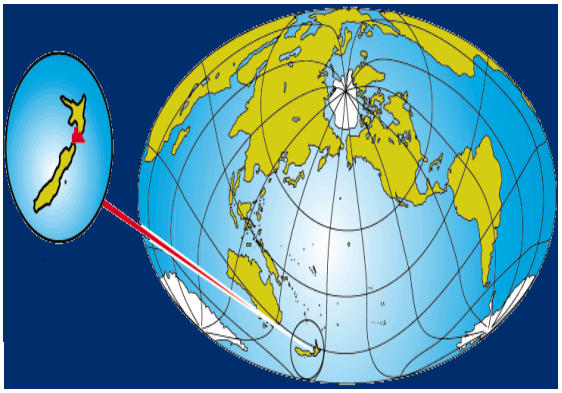

Figure 1. New Zealand in relation to the rest of the world

Within these projections there are regional variations. For example, the West of the country will become wetter, the East drier (Wratt, 2002), and temperatures in the North Island will increase faster than in the South Island (Kenny, 2002). For the built environment, the most significant risk is related to an increased incidence of heavy rainfall events and subsequent flooding (Minnery and Smith, 1996; cited in Camilleri 2000). How is New Zealand's built environment positioned to minimise these future climatic risks?

3 NEW ZEALAND'S BUILT ENVIRONMENT

New Zealand's population is around 3.8 million people (Statistics NZ, 2002). We live in about 1.3 million dwellings and work in around 67,000 commercial buildings (Page, 2002; Quotable Value, 2000). 85% of New Zealanders live in urban or suburban environments – one of the highest rates of urbanism in the world (PCE, 1998). Because the tools under discussion in this paper were developed with New Zealand's homes and offices in mind, an understanding of what an average home or office consists of, and how it may or may not cope with future climate risks, if of particular interest.

3.1 The Average House

1.3 million dwellings in a land area of 27 million hectares means that New Zealand's urban pattern is one of low density with relatively large geographical spread. Despite this spread and regional variations in climate across New Zealand, the housing stock is relatively similar in style and design (Saville-Smith, 1998). The average age of the housing stock (using 1999 figures) is 30-40 years, with an average floor area of 140m^2 (Clark et al, 2000). Most houses are detached and constructed with timber framing and weatherboard cladding.

The majority of New Zealand houses are not designed to deal with extremes of cold or heat (Saville-Smith, 1998), are rarely air-conditioned, and are only marginally heated (Camilleri and Jaques, 2001). For instance, a typical New Zealand house is only heated in the mornings and evenings often in a poorly controlled manner (Stoecklein et al, 2001). Furthermore, New Zealand homeowners do not appear to be strongly aware of ways to protect their houses from environmental risk, or how to reduce their environmental impacts in general (Saville-Smith, 2000).

3.2 The Average Office

Offices are commonly built of concrete and steel with a trend towards lower rise buildings (97% being less than or equal to three storeys), and floor areas of more than 300 m^2. In terms of office space requirements, the average area has decreased from about 34 m^2/person in 1988 to 18 m^2/person in 1998 (Bayleys Research, 1999; cited in Jaques et al, 2000). For new offices that are less than 300 m^2, mandatory thermal envelope requirements (the same as for housing) are required. Recent New Zealand Building Code (NZBC) revisions now require similar energy performance requirements for larger commercial buildings (Stoecklein, 2002).

Only 12% of office buildings have air-conditioning but most are heated (Royds Garden, 1992; cited in Camilleri and Jaques, 2001). In general terms, it is not known how New Zealand's offices will cope with climate change. There is research which summarises potential changes in comfort levels with buildings that are air-conditioned compared to those that area not (Camilleri and Jaques, 2001). But what is clear is that if a particular building does cope well, it will be by accident rather by intent (Saville-Smith, 2000). It would appear therefore, that both homes and offices in New Zealand are some way from being climatically responsive.

4 NEW ZEALAND'S POLITICAL CONTEXT

In global terms, New Zealand's greenhouse gas emissions are small. The economy is largely reliant on primary production and hence has much to lose (and gain) with climate change (MfE, 2001). The New Zealand Government has signalled its intention to ratify the Kyoto Protocol in September 2002. At the time this paper was written the preferred policy mechanisms to meet out obligations under the Protocol had yet to be released. However, it is reasonably clear from the supporting documentation and Government Strategies[2] released to date that there is a strong focus on mitigatory measures, particularly energy efficiency, to meet New Zealand's targets.

Whilst the focus on mitigation is important, equally important is clear, consistent advice on adaptation strategies. This is because even if all CO_2 emissions stopped today, New Zealand and the rest of the world will continue to have the effects of climate change to deal with for at least the next 100 years. Under the NZBC, buildings are designed and built to last 50 years (unless nominated a lesser life), with many buildings lasting up to 80-120 years or more. Future climatic risks must therefore be taken into account now as buildings built today will potentially still be functioning in 2100. The Government policies released to date do not provide adaptatory advice for built environments. The burden lies with the owners of buildings and associated infrastructure.

But as eluded to above, typical homes and offices in New Zealand are largely unprepared for climate change in general, or how to mitigate for, or adapt to, the likely impacts. The remainder of this paper describes two ways in which BRANZ has attempted to provide support and advice to the New Zealand building industry in this regard.

5 THE MITIGATION TOOL

The mitigation tool, based on the concept of '*Becoming a Climate-Friendly Citizen'* is a paper-based publication focussing on greenhouse gas reduction measures for homes and small- to medium-sized offices. In addition to providing a whole range of practical tips to

[2] Government Strategies released to date, which have greenhouse gas emissions reductions as a secondary goal, include the Energy Efficiency and Conservation Strategy (www.eeca.govt.nz), the Waste Minimisation Strategy (www.mfe.govt.nz), and the Land Transport Strategy (www.transport.govt.nz).

reduce greenhouse emissions, it includes a New Zealand-specific 'carbon calculator' so readers can work out their emissions on a monthly or yearly basis. The calculator was included as a 'measure to manage' instrument, based on the premise that you can't manage (or reduce) your emissions if you don't know what they are. Because the calculator is paper-based and thus highly simplistic, it only focuses on CO_2 emissions from energy, heating and transportation for homes, with paper use added for the office section.

The main objective is to support opportunities for the New Zealand public to actually do something about climate change in the areas where they spent the most of their time – at home and at work. The main output is a user-friendly, fully illustrated colour booklet. The reader is taken through what climate change is all about, and how it relates to them. It describes greenhouse gases and where they come from. From here the focus shifts to the emissions that the individual is directly responsible for, namely energy use.

Following this, the remainder of the booklet is dedicated to taking action to reduce emissions. For electricity use, tips are provided for lighting, appliances, water heating, insulation and windows. Tips are also provided for transport, reducing paper use and other recycling opportunities. To satisfy those readers who want to 'cut to the chase', a 'Quick Tips' section is provided along with lists of relevant web page links to further sources of information and web-based carbon calculators. The booklet is part of BRANZ's 'Easy Guide' series of publications and will be available for downloading from the BRANZ website in due course (see www.branz.co.nz under 'resources'). In summary, this tool is a timely publication that provides easy-to-use, practical information for individuals on how to reduce their greenhouse gas emissions on a day-to-day basis.

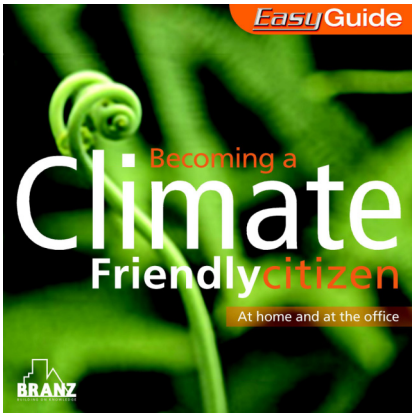

Figure 2. Front cover of the BRANZ mitigation tool

6 THE ADAPTATION TOOL

While mitigation refers to measures taken to reduce greenhouse gas emissions, adaptation refers to actions taken to minimise threats or risks and to maximise opportunities arising from the effects of climate change (Kenny, 2002). The *Coping with Climate Change* Bulletin (Hargreaves, 2001) is an adaptation tool produced by BRANZ that offers practical advice to the building industry, government and building owners for preparing for the challenges of climate change – both now and in the future.

BRANZ's Bulletins are a publication series that contain easily readable 'good practice' guidelines on a wide range of topics related to building and building performance. They are concise A4 sized, fold-out brochures with moderate technical focus. This particular Bulletin details the climate changes that are likely for New Zealand's built environment and what can

be done by the building industry. More precisely, it describes specific actions that home and office owners can take to future-proof their buildings against potentially more severe climatic events.

Before providing examples of what these actions are, the Bulletin quantifies some of the direct effects of climate change of interest to the New Zealand building industry. Of these, the most important effect is that any building with an existing flood risk may flood up to four times more often than before, and there may be increases in building damage from coastal flooding, erosion and rising water tables. In addition, there is a possibility that tropical cyclone activity could increase, increasing the likelihood and intensity of severe weather, primarily in the North Island.

After setting the scene, the Bulletin goes on to describe ways of dealing with these effects. Measures to future-proof for flood damage includes advice on building site location, building design including componentry, and references on how to recover after a flood event. For the increased risk of tropical cyclones, the Bulletin outlines actions to increase structural strength of buildings and pays attention to weathertightness. The advice covers what can be done in terms of both new and existing buildings, and consistent throughout is the need to consult with building professionals where appropriate. In summary, this tool, a first in New Zealand, offers people the means to respond to climate change in accordance with their circumstances.



Figure 3. Front cover of the BRANZ adaptation tool

7 SUMMARY & FUTURE DIRECTIONS

New Zealand is a small island nation in the South Pacific with much to lose (and gain) from climate change. It would appear that, in general, New Zealand's built environment is currently not well placed to minimise the identified risks or maximise benefits. The Government has indicated its intention to ratify the Kyoto Protocol in time for the World Summit on Sustainable Development in September this year. This sends a clear sign that climate change is an important issue for the New Zealand building industry to focus on.

As buildings have a relatively long life with slow turnover, tools that give specific advice on how to mitigate for, and adapt to, the predicted climate change impacts are both timely and relevant. Two such tools, one each on mitigation and adaptation, have been described. They aim to assist the public to reduce their greenhouse emissions at home and at the office, and to begin to prepare these buildings against future impacts.

While both tools are simple paper-based publications at present, possible future directions include the development of the carbon calculator in the mitigation tool for a web-based programme for enhanced ease of use and increased sophistication, e.g. under 'kilometres travelled by car', the type of car, number of passengers, type of fuel, etc could be included. There is also potential for a 'schools' version to be produced. The predictions and practical tips of the adaptation tool will need to be periodically revised as certainty in climate change scenarios and government policies evolve, and as new technologies emerge to help the adaptatory process. The same goes for the tips in the mitigation tool.

Whatever the final directions, the aim of these tools whether focussed on mitigation and/or adaptation, is to demonstrate practical solutions for the building industry so that New Zealand's built environment is climatically responsive in the years to come.

8 ACKNOWLEDGEMENTS

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A better environment depends on how our buildings are operated - Growth and greater welfare can go hand in hand

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1. INTRODUCTION

Two evaluations illustrate the possibilities for combining economic and environmental objectives. The basis is operation over a 30-year period.

One of the two evaluations, see Ref. (A), covers 12 experimental housing projects with 500 homes, in which great importance has been attached to using and testing environmentally sound solutions.

The other evaluation, see Ref. (B), covers 11 experimental housing projects with 600 homes, with the aim of improving the quality in general.

The results of the two evaluations provide a picture of future conditions and possibilities for sustainable building. It is pointed out that it will be possible to combine economic growth in the form of environmentally sound solutions and greater welfare with less impact on the environment – without extra total life-cycle costs.

2. GREAT PROSPECTS FOR MORE ENVIRONMENTALLY SOUND BUILDING

An evaluation (A) of 12 experimental housing projects with environmentally sound solutions that have been built within the last five years shows that it pays to increase the investment in a building project by 5-10% for environmentally sound solutions. The extra costs are made up for by cheaper operation.

If the number of environmentally sound solutions, and thus the investments, is increased by up towards 20% compared with traditional building, the increase in the cost of the housing will in most cases be around 5%.

The exact figure will depend on local conditions and any special wishes the developer and the users may have, just as architecture and structural design may play a role. The basis for evaluating the environmentally sound solutions is life-cycle cost analyses covering both construction costs and later operating costs.

It is a case of finding the right combination of environmentally sound solutions. For some solutions, the additional construction costs will not be made up for by lower operating costs.

However, planned work on environmentally sound solutions is at present only going on in a limited number of housing projects. There are several reasons for this – for example, a desire to keep construction costs as low as possible and a lack of competence in performing life-cycle cost analyses. That is evident from an evaluation (B) of 11 housing projects with around

600 homes, where the aim was better quality in general and higher productivity. The projects in question were built between 1995 and 2001.

In six of the 11 housing projects (B), no special effort was made to incorporate environmentally sound solutions. In the other five, the main form of environmentally sound solution was the use of wood. From the evaluation it is also clear that fluctuations in market prices may give rise to considerable uncertainty in the evaluation of the consequences with respect to life-cycle costs in the individual project.

However, generally, it can be concluded that there are great possibilities for more environmentally sound building and thus for reducing the environmental impact of housing projects. This offers both formidable challenges and new business opportunities for the building industry.

3. HOW THE ENVIRONMENTAL IMPACT FROM BUILDINGS CAN BE REDUCED

In the housing projects, see (A), in which particular importance was attached to environmentally sound solutions, 25 different solutions were used to a varying extent, depending on the individual project.

The 15 environmentally sound solutions fell within the following areas: heating (8 solutions), water (3), electricity (4), indoor climate (2), refuse (1), materials (2), green recreational areas (3) and user behaviour (2).

Examples are energy glazing, glass in solar heating systems, better internal distribution systems for heating, thermal insulation and the use of daylight.

In three of the housing projects with environmentally sound solutions, an extra effort was made to incorporate the solutions from the very start in the concept phase. This was in a competition in which importance was attached to the consideration of environmental factors and the incorporation of environmentally sound solutions in the design phase of the projects – instead of at the final stages.

In the other projects, use was largely made of solutions that had already gained ground when the individual projects were being planned and built. However, the evaluations show that improvements are gradually being made to the individual solutions.

In conclusion, the two evaluations show:

- that environmentally sound solutions are not yet part of the designers' toolbox when structures and installations are being chosen
- that the environmentally sound solutions are being improved by a small group of 'spearheads'
- that a range of environmentally sound solutions exist where experience is already available and is being incorporated, albeit slowly.

4. A BETTER ENVIRONMENT DEPENDS ON THE OPERATION OF OUR BUILDINGS

All the housing projects, see (A), with environmentally sound solutions have lower heat consumption than required in the Building Regulations – up to 50% lower. Consumption

varies greatly from home to home in the individual housing projects – in some cases, between 100 and 200% in relation to minimum consumption. This is due to differences in the tenants' habits with respect to their use of hot water, room temperatures, ventilation, etc. and shows that tenant behaviour has considerable effect on resource consumption in the home.

This difference in the behaviour of the tenants is clearly reflected in the differences between two identical housing projects in two different towns. The heat consumption in one project is only 74% of the consumption in the other, despite the fact that the homes in that project are more exposed to the elements than the homes in the other project. The big difference is attributed to tenant habits, the tenants in the project with the lower consumption having been selected for their interest in environmental issues, while those in the other were selected on the basis of a normal waiting list.

These examples show that the tenants' interest in using environmentally sound solutions plays a vital role. The tenants' habits are also reflected in the water consumption in the housing project with the low heat consumption which is approximately 20% lower than in the other housing project.

In the case of electricity consumption it is difficult to achieve savings in structures and installations. Here, however, there is a difference, too, between the two housing projects that indicates that the tenants' habits can produce savings.

It is thus important to note that environmentally sound solutions are only the first step. The next is to monitor the solutions and use them during operation. Operating personnel and users thus have an important role to play.

The same solution, see (A), may produce very different results in various housing projects and, in some cases, worse results than would a traditional solution.

5. MAJOR BUSINESS CHALLENGES – AND OPPORTUNITIES

The two evaluations show a marked difference between housing projects in which the planning included careful evaluation of environmentally sound solutions and projects where the aim was a general improvement of the quality.

At the same time, the life-cycle cost analyses show that there are a number of environmentally sound, "off-the-shelf" solutions that it would be advantageous to use, both environmentally and from the point of view of life-cycle costs.

The question is therefore why they are not used in practice. The evaluations do not offer an answer to this question but point out that the reason may be that both politicians and developers want to keep construction costs as low as possible. Other barriers are lack of competence in using life-cycle cost analyses and the unawareness of environmentally sound solutions.

There is therefore a need for coordinated and coherent action by both developers and the building industry to get the environmentally sound solutions firmly placed in the box of design and construction tools.

There is a need for a strategy to solve these tasks and to ensure that the business opportunities are utilised. This will at one and the same time create growth and greater welfare.

6. EVALUATIONS:

(A):12 urban ecological experimental housing projects
Experiences and recommendations
Evaluation Report
Danish National Agency for Enterprise and Housing 2002 (in press)

(B):Process and Product Development
Evaluation of 11 experimental housing projects
Danish National Agency for Enterprise and Housing 2002 (in press)

Building with cardboard: the reality

Andrew Cripps PhD[1]

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1. INTRODUCTION

At the conference in Maastricht we reported on the development phase of the cardboard building being designed for Westborough school, in Westcliff-on-Sea, England. The building is now complete and being used by the school.

This paper reports on the reality of delivering a cardboard building. It presents a review of the environmental impact of the building, and whether the compromises needed to make cardboard work defeat the object of using cardboard in the first place.

The way in which the building was put together is also reported on. From this ideas on how to make cardboard building economic are developed. It is significant that although the raw materials are cheap, unless the processing can be made efficient, building with cardboard is actually an expensive way to build.

Finally we present ideas for future directions for cardboard that we are considering, or that could be taken up by others.



Figure 1: View into building from North side



Figure 2: Card tube used for air supply in toilet

2. WHY BUILD WITH CARDBOARD?

Cardboard has the potential to be a very valuable contributor to more sustainable construction in the future. It is made mainly from post-consumer waste paper and card, which is a material for which there is a limited market. The cardboard itself can in turn be recycled into more cardboard at the end of its life. The paper is of course originally sourced from timber (or other crops) and so is from a renewable source. Hence the raw material is an ideal candidate for any sustainable application.

Shigeru Ban is recognised for having led the way in cardboard building [Ban] and Buro Happold has been fortunate to have been able to work with him on a number of projects. These include the Japanese Pavilion at the Hannover Expo, and an arch in the garden of the Museum of Modern Art in New York. Perhaps more importantly he also devised an emergency shelter system using cardboard.

In terms of performance, cardboard like any material has a set of properties, and these are then affected by the form in which they are used. It will of course be obvious that these need to be considered when using the material, and the limits observed. Because we most often see cardboard in the form of packaging, we tend to think of cardboard as a very weak material, and one that burns easily. In fact it can be reasonably strong (we used a figure of 8 N/mm^2), and in a solid form is resistant to fire in the same way that timber is.

By using these properties we were able to use cardboard in a number of ways in the Westborough school project:

- Structural columns
- Partly structural panels for walls and roof
- Insulation (in the same panels)
- Air supply ducts

The largest user of cardboard is in the wall panels. These mean that around 30% of the volume of material used was cardboard. This rises to 50% if we ignore the floor slab, that was designed to allow any solution to be built on it - if we doing another project we would try to avoid using concrete for this. Of course by weight the percentage is much lower, because card (especially as honeycomb) is so light.

The walls and roof were calculated to have a 'U' value of around 0.3 W/m^2K, comfortably better than the Building Regulations for the UK (0.45). The card system is therefore able to play both a structural and thermal insulation role at the same time. It would be valuable for the thermal performance to be investigated in detail.

The extent of the potential strength of cardboard was demonstrated by an experiment carried out for the BBC TV programme 'Tomorrow's World'. We designed and built a bridge using the same
materials as the building, and it was more than strong enough to carry a car - see figure 3 below.

The final positive property to raise is the relative cheapness of the raw material. The 5 mm thick board costs of the order of 2.5 Euro per m^2, while the tubes cost around 3 Euro per linear metre for a 20 cm diameter tube. It is very important to note that the raw material may be cheap but the processing to make it work is not necessarily as cheap, and the end product may not be as competitive as expected.



Figure 3: Car on cardboard bridge

3. THE PROBLEMS OF BUILDING WITH CARDBOARD

The reader of the previous section may emerge wondering why cardboard isn't being used everywhere already! Of course there are reasons, some of them are associated with the weaker features of cardboard.

3.1 Creep

Creep, or visco-elastic deformation under load, affects all materials to some extent, but because of the shorter fibres in card, it is affected more than timber for example. As a result it is only possible to use a small proportion of the potential full strength of cardboard for long term loads. We used a factor of safety of 10 for the load bearing columns. The wall of tubes in the picture below would work with only 2 tubes for a short period. In the panels making up the walls this problem is avoided as they are edged with timber, and this helps to carry the permanent loads. The card does provide stiffening to what is effectively a timber frame, and carries wind loads.

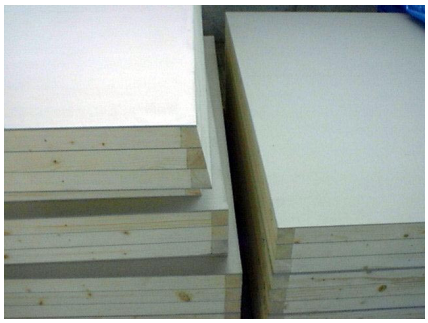

Figure 4: Panels showing timber edge

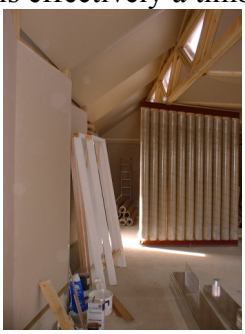

Figure 5: Tube wall in place

3.2 Water

The reason that card can be recycled is that the glue that holds the fibres together is soluble in water, meaning that card is vulnerable to water. In order to use it, card must either be protected from water, or treated to make it waterproof itself. This is one of the principle compromises that must be made in using cardboard.

There are a number of possible additives that can give cardboard different levels of protection from water. The most effective of these leave the material not as cardboard at all, but a composite board of some sort, usually with a non-recyclable resin of some sort binding the fibres. However

the completely untreated card tends to absorb water from the air, and so is vulnerable to normal conditions. Hence we chose to use a water resistant additive commonly used by the board maker to prevent this absorption, but to leave the cardboard recyclable.

To provide the protection from bulk water, there is no alternative to covering the surface with something else. At Westborough we used a very thin 'poly' layer in the inside, and a more robust building paper on the outside, followed by a fibre-cement board as over-cladding. This outer layer also provides impact resistance, and fire protection. This over-cladding is another aspect that could probably be improved upon in another project. We also built the main structure under a temporary roof.

3.3 Fire

Obviously paper burns, but solid card is more inclined to char than to burn rapidly. In a fire test carried out for the project a solid 5mm board narrowly failed the test for 'Class 1' spread of flame, which is a very onerous test. Given the size of the building we could have quite easily used a fire engineering argument to remove the need for any fire protection, as it is most unlikely that any loss of life would occur in a fire. However this does not account for the damage to property, and so we decided to treat the exposed card surfaces (the ceiling) to give better fire resistance. The images below are from another test for the Tomorrow's World programme, and show the flame being applied and the limited damage that this caused.



Figure 6: Fire test underway



Figure 7: result of fire test

3.4 Costs

As raised earlier, the raw material is very competitively priced. In our project however the cost of the processing to deliver the panels meant that it would have been cheaper to have used conventional bricks and mortar - and much easier for the builders. This is not however in the nature of the material but in the fact that the industry is not developed to deliver the product in a cost effective way. This leads into the next section.

4. THE FUTURE FOR CARDBOARD IN CONSTRUCTION



Figure 8: The finished building

What the successful delivery of the Westborough School after-school club building shows is that there is potential to use cardboard in a variety of ways in mainstream construction. What it does *not* show is that there is a real future for cardboard in construction.

Following the completion of the project we have had a very large amount of press and media interest in the project, with at least 100 articles written and 25,000 visitors to the project website, www.cardboardschool.co.uk, especially following a broadcast on CNN. However in spite of a large number of expressions of interest, at the time of writing we are not working on another project of a similar nature.

The way forward?

For cardboard to play a part in more sustainable construction it needs to find a market role where it can win a significant market share. Although one-off projects are excellent for raising awareness, it is the bulk of material that matters - we need thousands of tonnes of it to be used, displacing other more energy and raw material intensive materials. Further it has to work well in these applications so that the whole life impact is reduced.

It is unlikely that there will ever be many whole buildings built mainly in card. The structural performance is such that for most circumstances other materials will be better. The Westborough project was seeking to use card everywhere possible as a demonstration of what can be done, and is not expected to replicated directly.

Hence the next step needs to be a move toward more commercial, large scale development of one or a number of products based on cardboard. One or a number of organisations will then need to invest the resources needed to turn an idea into a real commercial product to compete in the market place. This must involve mass production of some form, if card is to compete with other materials.

There are many ideas floating around that could work, and we are hoping to be involved in developing a number in the future. The most obvious include:

- Panels for internal walls
- Ceiling or floor panels
- Temporary, cheap buildings
- Emergency shelters
- Garden buildings
- Parts of system-built structures

There are already some applications where cardboard is used, particularly in doors and some types of furniture, and the tubes are used for column forming and piling. What we see as likely to happen is the gradual appearance of a number of other products, to allow the use of cardboard to grow in construction.

5. CONCLUSIONS

In the Westborough School project it has been shown that cardboard can play a useful role in a bespoke, demonstration project. The question going forward is whether there is a place for the wider use of cardboard in construction?

The conclusion of this work is that there definitely could be, but that it will take a number of further commercial developments and financial investments to make it a reality. If this happens then cardboard can play a part in making construction more sustainable.

REFERENCE

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Recovery of the building known as "Mill of ca la Daniela" S.XIX

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1. HISTORIC MEMORY

The Spanish history of the XVIII century appears in a setting touched by the nostalgia and the evidence of the loss of power and the influences it disposed of during the centuries XVI and XVII, this together with the change of dynasty, the Austrias were substituted by the Borbons at the beginning of the XVIII century and the change of an autonomous vision of the different kingdoms of the same crown of the reign of the Austrias to a centralist conception of the Spanish kingdom which the Borbons imposed, together with the Napoleonic wars of the beginning of the XIX century, meant a delay in the industrialization of Spain.

For this reason the first industrialization takes place with the application of water as a power source, transforming flour and paper mills into textile factories, due to the royal decree of the 30 of April of 1832 that forbade the introduction of foreign textile manufactures.

Due to the protectionist measures of 1832 the process of industrialization in the textile sector begins in Spain.

The mill of ca la Daniela is one of the first industrial constructions built in Sabadell and conceived for what it was designated, it's construction dates from the year 1850; the building has in its body the pace of the Spanish history from the XIX and XX century, this article wants to show the desire of a building to reappear like the fenix bird of pray, keeping an historic line to serve the industrial activity for which it was built.

One has a first vision of the building in the photograph nº 1 where one can see the mill of ca la daniela as it was in the year 1888.

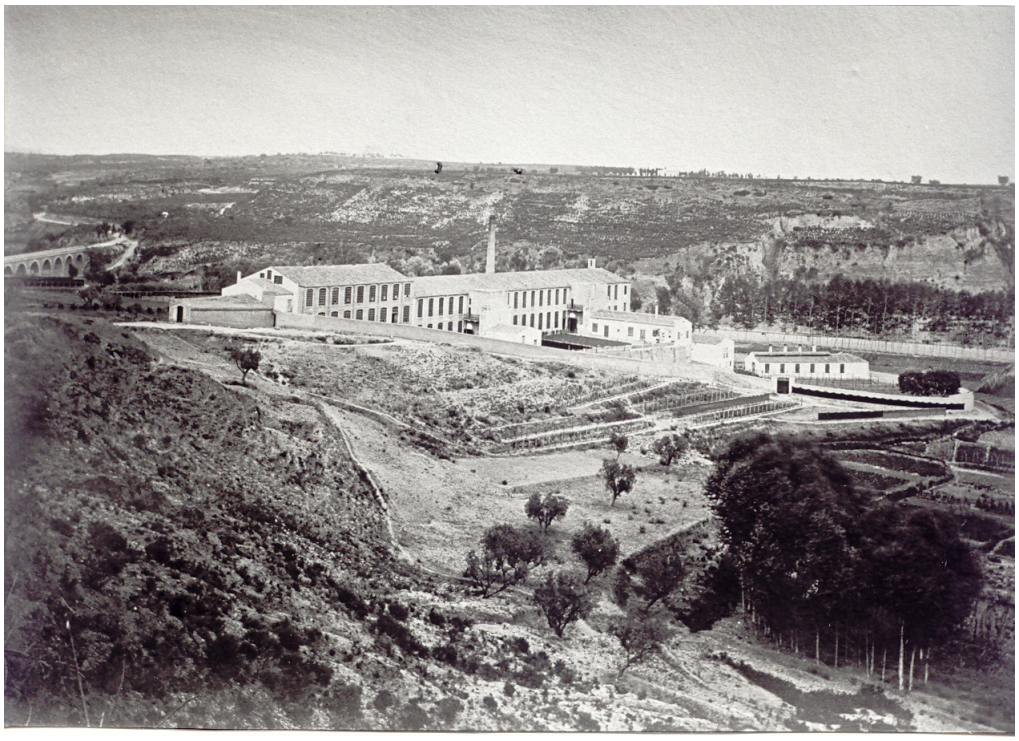

Figure 1

We dispose of the plan of the same year (picture nº 2), which was presented to the Town hall to ask for a license to renovate the existent machinery and to install a new steam machine.

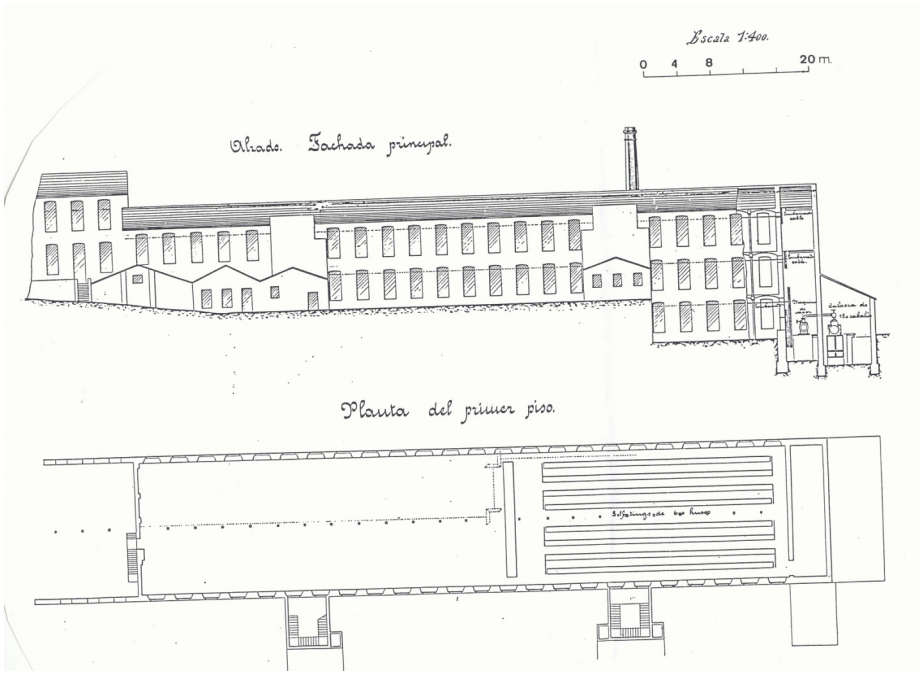

Figure 2

The building was injured again later on during the retreat of de General Lister's troops in the Spanish civil war of 1936-39 as one can appreciate in the photograph nº 3.



Figure 3

The chimney will be torn down in 1964 due to the fact that carbon will be substituted by fuel for the feeding of the boilers and a few years later Spain will abandon the electric restrictions and the steam machines lost their use as one can see in the photograph nº4; but the Spanish industrial

development meant a period of prosperity and ca la Daniela increased its dimension as one can see in photograph nº 5 corresponding to the year 1982.



Figure 4

The history of ca la Daniela continues and the building was partially destroyed by a fire in the 1.996, as one can see in the photograph nº 6.

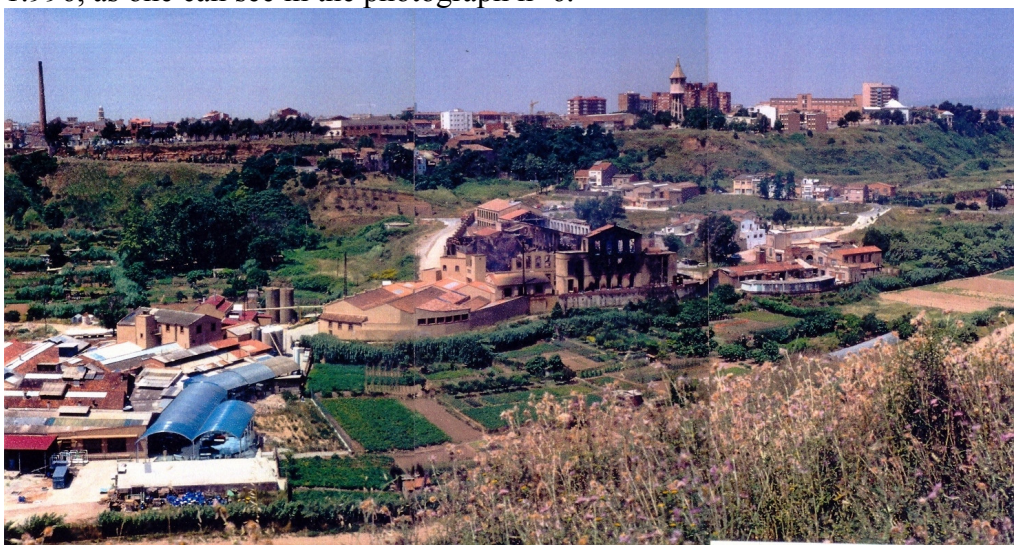

Figure 5

2. RECONSTRUCCION OF THE BUILDING-

The owners of the building conscious of their historic and social implication have wanted to rebuild the building in a way that although following the criteria of Sustainable Construction it has adapted to actual requirements.

For this reason "One has tried to recover the building respecting it's spirit, understanding this as what it was in it's time, and that we can enjoy this singular building at the beginning of the XXIst century. Sabadell's pride and drive in the XIXth century were represented, today it has to represent the capacity of that spirit to endure; respecting:

- The remembrance of the building mentioned above.
- The criteria of the sustainable construction, which takes into consideration:
  - Respect with the environment.
  - The endurance of the social and economic impact of the Industrial activity.
  - The Institutional relations.

And for this reason to keep the memory of the building, trying to conserve its aesthetics.

- To assure its endurance, give it the right structure for the industrial activity of XXIst century.

For this it has been designed with the following characteristics:

- The floors have to have a minimum 6m utile height.
- One has to try to get a main line of pillars that doesn't create the sensation of a forest of pillars, this is why one has adopted the 8'60x8'60 in function with the disposition of the site.
- The utile overweight has to be adequate with the mechanical bulls trajectory , operated by an electric motor and taking into account the weight of the batteries, in other words, for a punctual overweight of 5000 kg and a distributed overweight of 1500 kg/m^2
- The foundations are dimensioned for an overweight of 2000 kg/m^2
- The connections between floors will be concentrated in one point to try to avoid the propagation of fire if there is one.
- Each floor will have an exit to the exterior with loading and unloading docks for lorries.

These would be the demands for an industrial building if it had the will to endure.

3. FUNCTIONAL PROGRAMME OF THE BUILDING

The Industrial building proposed to be reconstructed is planned divided in two blocks; one is the little nave which has not practically been affected by the fire, it has two plants destined to administrative uses and another one constitutes the reconstructed building formed by three plants destined to industrial use, basement, ground level and superior level.

Four parts have been planned:

- The main body is characteristic of the building called *"Ca la Daniela"*.
- The second body composed by two lateral naves attached to the central nave, with one plant less to be able to highlight the vision of the central nave.
- The third destined to the vertical element of communication between plants which at the same time serves as the hall and a space to show the recovered steam machinery, limiting its height in function of the communication core, leaving it fifteen centimetres underneath the cornice of the little nave in order not to lose its vision.

- The fourth destined for an area of reception and expedition of merchandise goods from the superior plant with a direct connection with the superior nave.

In the essay of the project the constructive solutions will be analysed under the influence of the last contributions from the "Sustainable Construction" ambit and especially by the ones derived from the 2nd Building and environmental International Conference celebrated in Paris in June of 1.997 and under the criteria of the persistence of the historic memory, the following solutions have been foreseen:

The naves
It was decided to continue with traditional vision and to keep the step between the big Nave and the small Nave, following the criteria of sustainability, the walls will be reinforced concrete and the existing windows of the old nave will be reproduced, the roof structure will be made out of wood on which the wooden guides lean on and a chain which acts as a fire protection element, on the inferior part there is a timber sheet of two millimetres on which the insulation where the flat type roof slates will be placed to make the lecture easier of what is pre-existent and what is new.

Vertical communication area
It is the communication core between levels, one has thought of making use of the entrance space to create a bio climatic area which at the same time gives a major benefit to the reception which is an area to situate the steam machine as an representative element of what the beginning of the industrial activity was, the enclosure is formed by reinforced concrete walls in the factory elevations and a curtain wall in the administration levels, one has to stand out the proposal to create a "sunshades" on the south wall which projects its shadow on the office area, the lower part of it is glass to give a sight of the steam machine from the exterior.

4. ENVIRONMENTAL ANALYSIS

One could not think of not effecting an environmental analysis of a building of such characteristics, for this reason it is necessary to study in an accurate manner the materials and its designated functions.

Just as it was indicated in the Conference of Paris of 1997 in the Mediterranean climatic area in buildings without air conditioning it is more necessary ventilation than central heating and that the energetic consumption is destined to the first one. For this reason one has foreseen a system of windows which give crossed ventilation in order to make the air renovation of the nave easier.

In the buildings mentioned the major impact comes from its materials and in a special way in the following points:
- Construction ruins
- Maintenance
- Excess of materials because of an exhaustive over dimensioning.

For this reason concrete has been used as a basic element because it doesn't leave ruins such as in the use of brick, the maintenance is most essential because there aren't any skim or one coat coverings, prefabricated and pre-tensed structures have been used in order to avoid over dimensioning.

In the zones without air conditioning one has saved up on the aluminum frame and one has looked for a glass solution formed by two leaves and a sheet of butiral , at the beginning for esthetic reasons and later on also environmental ones.

By the contrary in buildings with air conditioning the element with major impact is the air conditioning system in which two facts have to be considered:

- That the same air conditioning system is respectful with the environment.
- That the building has a low energetic consumption, this is accomplished through:
    1. A good insulation.
    2. The use of double glass systems with an air chamber, which have a high reflecting factor in the exterior and a low emission in the interior.

Taking into account that in the Mediterranean climate solar radiation is of major importance, all the roofs are perfectly insulated and are the ventilated type.

5. CHARACTERISTICS OF THE RECONSTRUCTED BUILDING

The building mentioned previously will be composed by three naves, two lateral ones in two levels and a central nave in three levels.

- Conserving the office nave of two levels, which was saved from the Fire.
- The reconstruction of the building proposed, in a way that it is formed by:
- A central nave of two levels and a basement that together with the office area gives a primitive vision of the steam factory.
- Two attached naves on each side of the central one formed by basement and ground level which constitute the plinth on which the central nave stands out.

From which the following building parameters are given:

Areas:	Existent	Rebuilt	Built
	Office level		460,33
	Office level		460,33
		Level 3	1.692.-
		Annexes level 3	262,46
		Level 2	4.437,75
		Level 1b	307,51
		Level 1	4.311,35
		Annexes level 1	231,07
Total			
Total	**12.162,80 m^2**		**7.190,38 m^2**

In photograph nº 7 one can appreciate the reconstructed Industry.



Figure 7

The protection and recovery of the architectonic heritage of the XIX century in the city of Sabadell (Spain)

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SUMMARY
Sabadell is a city, which owes its expansion to the 19th and first half of the 20th century, subsequently there has been construction over the base city. In this context a plan has been redacted to protect the architecture of the 19th century that actually might appear old; however if we do not protect it the indiscriminate demolition will cause their disappearance by the middle of 21st century.

1. BACKGROUND

Sabadell with 192.362 h. is the city with the most population in Vallés. Valles is one of the historical region of Catalonia, as indicated its name is a great valley which extends from east Catalonia between the Littoral, Prelitoral mountain range and Montseny, it has a million inhabitants which represents 16.66% of the population of Catalonia, with a surface area which occupies the 4% of the territory, if we classify it in accordance with the PIB it will be the forth Spanish province after Barcelona, Madrid and Valencia.

Sabadell is one of the largest cities created from the Spanish industrialization, for that reason it has been a city which has a population built of migrant workers, as proof of this fact during the 19th and 20th century it has been an important destiny for the mentioned migratory workers in the year 1800 the surface area was 2.822 hectares, in 1850 -10.157 h., in 1900 – 23.294 h., in 1950 it reached 59.494 h., in 1960 – 105.152 h. stabilizing from 1980 – 189.630 h., during the last decades of the 20th century it has converted into one of the principal poles of attraction of Barcelona's metropolitan environment.

The mentioned facts, have led to the reconstruction of the surface area which have left the industries in the normal evolution to leave the city centre. Leading to a change urban landscape, for that reason the city council has introduced, what in Spanish urban legislation is called *"A special plan for the Protection of Urban Patrimony of 20th"*.

The work, which is presented, is the reasoning realized in rethinking the city.

Considering that the city is not the equivalent of a concentration of residential zones, although at times it is a solution, however they are never equivalent to that. The city is complex and with live, it has a birth, a period of growth and also enters into decay.

The virtues of its birth, depends in a large extend, which could give a solution to the needs which arise and which permit the adaptation to the new conditions.

The city therefore has to be understood as something changeable, which permits mutation, because it is intrinsic to its own existence, because its related to its genetic make up.

It is also a place of relationships, at times an interim place, for that reason it is important the design of that meeting space: **public space**; as the channels for this communication: **the infrastructure.**

As or more important, therefore, that the architecture specifies, is the treatment of its public spaces. Protect them means conserve the mold of the urban history.

To respect the personality of Eixampla of the 19th century, the textile industry of Sabadell, signifies being preoccupied concerning the maintenance of the traces of the public spaces, the structure of the plots (scale) and the austere architecture, which identifies the city.

2. INTRODUCTION

Up until recently the word landscape was inevokably associated with the countryside, in a way in which it would seem a clash to unify landscape with urbanization. Now it forms part of the common language and even proposed the regular intervention in the urban landscape of the historic fabric of 19th century of Sabadell.

This urbanistic document rests on various pillars:

- It is connected with the idea of a historic patrimony understood as a collective memory; with the reality of the urban space understood as the inductor of the argument, the fabric with the collective right to dispose of an organized environment respectful of the past;
- With the idea of the city as a memory file and deposit of values to preserve; with the frontier of conflict between public and private rights.

Such an ambition is difficult to reduce in the frame work of organist regulation and for that reason is not possible to understand this document without unspecting to be complemented by the will of the social agents that participate as a body in the interventions in the urban fabric of the 19th century Sabadell (owners, promoters, technicians, civil societies and public administration).

At the same time they want us to regulate, in the common understanding of the term, special plan which intends to stimulate the collaboration of the agents in the base objective of respecting the persisting values of the industrial city of the 19th century too

As much as they wish to regulate, this project wishes to be situated in a framework of work and limits of the prescindable initiative of the agents involved.

More than regulate intend to save, or better preserve, values of the urban landscape, which the spontaneity of the interests of the sector could possibly damage. At the same time they want us to regulate, in the end, wish to open a way to the contemporary architectural expression of culture limited only to the city's own cultural level.

Such as the industrial eixampla, as a worker's city, the Sabadell project at the middle of the 19th century and consolidated in the following 20 years has become the urban landscape easily identifiable. A singular city the result of an urban project related to the topography and the culture of the moment, and a rational architecture derived from social economic conditions.

"The process of the formation of the city of Sabadell", is based in skipping the lineal model of growth following historical methods to disperse in the squares of the eixampla "this has brought about a growth far more homogenic, without hierarchy, which has produced a certain monotony, due to the fact of not having introduced focusing elements in the interior of the squares: great palaces, boulevards, services," Circumstances which have favored an image of the city and urban landscape absolutely singular, which the present plan wishes to revindicate and to value.

3 ANALYSIS OF THE URBAN FABRIC OF THE 19TH CENTURY

3.1. Variants of urbanistic growth linked to the expansion of the textile industry

The arrival of the industrial processes caused an economic expansion, demographic and consequently urban of the populations related to the textile branch.

The small municipalities had to give way to steam and workers and this was done in different ways. The way in which this common form of "giving way" has differentiated the urban growth and has resulted in diverse city models.

For example, certain population separated the new industrial sites from the urban centre, forming nucleus peripheries, other populations grew like an oil stain and others projected an eixampla. These different forms of understanding urban expansion, have given space to the own specializations of cities equally industrial.

Faced with the urgent need to construct a city to house the new social and economic processors, Sabadell's option was to project an eixampla. The physical characteristics of Sabadell have an important place in the final formalization of this new urban fabric. Consequently faced with the diversity of networks and the destruction of the characteristic fabric we find in Sabadell the regularity of a unique way, which is resolved in all the Eixampla.

From the regularity of the plot, we can extract some of the features that define clearly the historical landscape of Sabadell: the visual strength, the perspective frame in between two parallel plans that cut out the sky, with the orthogonality always present.

3.2. Analysis of the historical evolution of Sabadell urban growth

Sabadell growth, in contrast to the majority of cities, it doesn't happen in a radial way.
In it's beginning it starts round the church and shortly after generates right next to him a closed market space for constructions round him.

Subsequently it starts to grow following Manresa's track and a lineal growth begins, characteristic of Sabadell.
Further on, the Eixampla Square disperses this lineality and at the same time it dilutes the radiality that the old roads formed with their confluence in the old center.
This model has ended involving a strong homogenic growth, and without hierarchies for the fact of not having introduced focalisation elements in the interior of the square: which can be great squares, avenues, and services.

This circumstance has helped to give a city image and an absolutely singular landscape and for that reason, characteristic of this city.

3.3 Analysis of the plot structure related with the typological models

One of the conclusions we get to from the analysis of the plot structure, it is clear the correspondence between the cadastral units and typological models. The map work of industrial places, *casals* and working class house, such as the posterior structural plot superposition, and this identification can be observed between building typology and the model plot.

To the plot's regularity, we have to add the homogeneity of the property structure. The correspondence between the cos cos unit and the cadastral unit has given place to a nearly absolute regularization of the property structure. On one side for the practically total identification between the uninhabited typology and the plot, on the other side because to resolve other typologies, often it has been chosen between the uses of different types of the same unit (*casals* of two or free *cossos*, square *cos* and half o two *cossos*…)
The exceptions in this plot reduce would be, majoritly , the big industrial pieces, they don't only stand out for the own expansion, they also do it for the cohabitation with the other typological models.

4 ADAPTATION BETWEEN THE INTERVENTION CRITERIA IN THE URBAN LANDSCAPE AND THE APPLICABLE PLANNING

Even that one of the first objectives of the *Pla General Municipal d'Ordenació Urbana de Sabadell (general municipal plan for Sabadell's urban organization)* was to guarantee the conservation of the morphological characteristics of the fabric, in some ways we can find discordance between this objective and the specified planning application, because with this Special Plan is complemented the definition that was done of this fabric, with the establishment of features and significant elements as landscape configurators; in specified aspects we can find contradictions between the historical fabric characteristics and the adequation of these characteristics to the applicable planning.

From the analysis of the applicable planning in our own ambit were we are involved, we would be able to establish certain discordances, as the affectations for widening the roads, that we can find in some points of the plot, that effect significant elements of the historical landscape, or difficult construction heights to achieve with traditional typologies.
The mapping of these discordances give a general vision of these historic fabric spans effected by the planning, at the same time that it let's us identify those conflicts, in another way, easily to be resolved with the ordering of volumes, a variation in the regulation height that permits the incorporation of a significant element of the historical landscape.

5 INTERVENTION PROPOSALS IN THE URBAN FABRIC LANDSCAPE OF THE 19TH CENTURY

5.1. Intervention criterias. Delimitation criterias

To achieve the objective of this Special Plan and to be able to guarantee that the regeneration interventions of fabric do not damage the urban landscape of the historical fabric, we expose 2 criteria's to classify the regulation interventions in function of the relative localization of actuation inside the historical fabric, on one side, and the elements characteristics specially on the one that the intervention is being happening, on the other.

The application of the first criteria comes from the historical analysis, typological and urbanistic of the Sabadells fabric, consolidated with the urbanistic expansion of the 19th century.

The application of the second criteria includes 2 different aspects that, come from individual analysis of each one of the elements from the point of view of his valuation as a configuretor or not of landscape, on the other side, the abstraction of the representative features of the interventions that have been produced in the fabric's origin in the 19th century like the composition of the front of buildings, the materials used, the developed typologies

5.2 Delimitation of the regulation areas

As a result the studies before mentioned, we obtain the delimitation of some specific ambits, the landscape characteristics in which, became unitary, unitary singulars, singulars and representative of their environment. As a consequence of these aspects 2 physical ambits are delimited that will generate slightly different norms. These 2 ambits are the generic regulation ambit (that contains the urbanistic expansion from the industrialization of Sabadell) and the specific regulation ambit

For the definition of the generic ambit regulation limits, it has been started from the superposition of the cartographic base done in 1916 for the *Redacció del Pla d'Eixample de Manich-Renom* (1928) and the actual cartographic base, with the consequent adjustments that come from the analysis of the fabric.

To define limits of the specific regulation we have excluded from the mentioned those zones, the landscape in which, even do they present defining features of the fabric of the 19th century such as the argument and constructed fronts, there is no special interest which makes it singular or representative of an environment. In contrast, we have included those parts of the fabric in which the interests of urban landscape that this fabric generates or of the plot in it self, do necessary the regulation of the future interventions with mechanisms that guarantee the conservation of the morphological features of the fabric and that help with the integration in the landscape of future actuations.

5.3. Determination of the characteristic elements

Regarding the analysis before talked about , we can put together the characteristics of the elements in two big groups; the significant elements of the urban landscape and the general features that configure the landscape

5.4. Significant elements of urban landscape

5.4.1 One of the values of urban fabric of the 19th century is the coexistence between elements of scale and different typologies but with a perfect integration in between them. The presence in these buildings scenery of important dimension as the industrial buildings are in coexistence with the industrial offices, hostals and the houses of *rengle*, do that the relationship between them, or its own physical characteristics, result significative which conform urban landscape. His recognition let's us affirm that these pieces or specific aspects. His recognizement let's us affirm that these peaces or specific fabric aspects have this referent value.

5.4.2 Significant elements in his volume. This category recognizes basically those buildings with industrial features disposed in different ways in the fabric, with good coexistence with minor scale elements and which act as a reference in the landscape. These elements, even of their evident presence, supports its discrete integration in the urban landscape, probably, in the modulation of the composition of the front of their buildings.

5.4.3 Significant elements, which form the front of the street. In the same line expressed in the introduction of this paragraph, in the urban fabric of 19th century Sabadell there are elements in which the relation between themselves, or the owns physical characteristics, result significative as forming the urban landscape. This is the case of certain street fronts, unitary or not, which finish generating an added value of the urban landscape. In this category are included those fronts of buildings which because of their dimensional contundency or the own special characteristic end up being a point of reference in the landscape recognized as being valuable. It is here in this group that we find complete and conform building fronts, fronts in which the value is the succession of individual building fronts, which join in a continuation with other building fronts of little dimension, which act as a reference in this fabric.

5.4.4 Significative typologies. It is imprescindible for the recognition and comprehension of the historical fabric the edeficative typologies, consequently producing the elements most clearly defined in Sabadell's landscape.

5.4.5 Free spaces. The free spaces from the fabric: the traffic plot, the urban parks, is the elements that more clearly identify as formers of the urban landscape, But they receive the consideration of free spaces as significant elements that configure the historical landscape, those emptiness in the constructed fabric that are necessary to understand the values of the own historical fabric and the elements that form part; independently of its public titularity o private.

5.4.6 Visual overtures. Guaranteeing some determinated visual overtures, permits to achieve the visual connections between significant elements formers of the urban landscape, and at the same time to keep a visual transparency, making that from the public space you can be able to read determined elements from the landscape, that for being from a private titulary have restricted entrance.

Integrated LCA-tool in Design Projects

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1. INTRODUCTION

Granlund is one of the leading building services consultants in Finland. The company specialises in the design of HVAC, piping, electrical, building automation, security and telecommunications systems and technical facilities management (FM) consulting services and software. Granlund has put a great deal of effort into integrating life cycle thinking into design methodology and also into developing design and software tools to meet the needs of cost effective and environmentally friendly design.

This paper describes how the integrated calculation tool BSLCA (developed by Olof Granlund Oy) is used for ecological design and analysis of buildings and building service systems.

2. AIM OF LIFE CYCLE CALCULATIONS IN DESIGN PROJECTS

The aim of life cycle calculations is to provide information to the building owner for decision-making in different situations, mainly in the design stage. In life cycle consulting the life cycle costs of a building are specified and the environmental impacts are analysed. The best alternative over an agreed life span can be found by comparing the effects of different approaches - usually the calculation involves different alternatives of construction and building services.

By applying life cycle calculations at an early design stage, the building owner or project manager can guide design, construction and maintenance towards ecologically and economically sustainable solutions. With the information available at the conceptual design stage it is possible to make reasonably accurate calculations of the life cycle costs and environmental impacts that can be expected.

In the conceptual phase the energy use and environmental impacts of different building shapes and structural solutions may be compared. In the following design phase different technical systems are compared using more detailed energy simulations and life cycle calculations. In the detailed design phase it is possible to compare the environmental impacts of system components.

Using project specific sensitivity analysis, the importance of different factors (especially those associated with operation and maintenance) to life cycle costs and environmental impacts can be determined. The results of this analysis can also be used in energy monitoring and in training facility managers and technical staff.

Simulations of energy consumption and indoor climate conditions play a key role in life cycle projects. The energy costs of a building that is designed and built in a cost-effective and

energy-efficient way are optimal and the indoor climate is suitable for the activity within the building.

3. LCA-TOOL STRUCTURE AND LINKS

3.1 Tool Structure

The Granlund LCA-tool BSLCA is a database solution with a Windows interface and it handles environmental impacts of the building envelope and the building services systems such as HVAC and electrical systems. The tool has been developed for integrated and/or interoperable design environment, where existing information can be used as an input for BSLCA. This means links to other design tools, such as architectural, technical system design, ducting and piping design and energy simulation software. The links utilise standard methods of exchanging design information with other software tools based on IFC (Industry Foundation Classes).

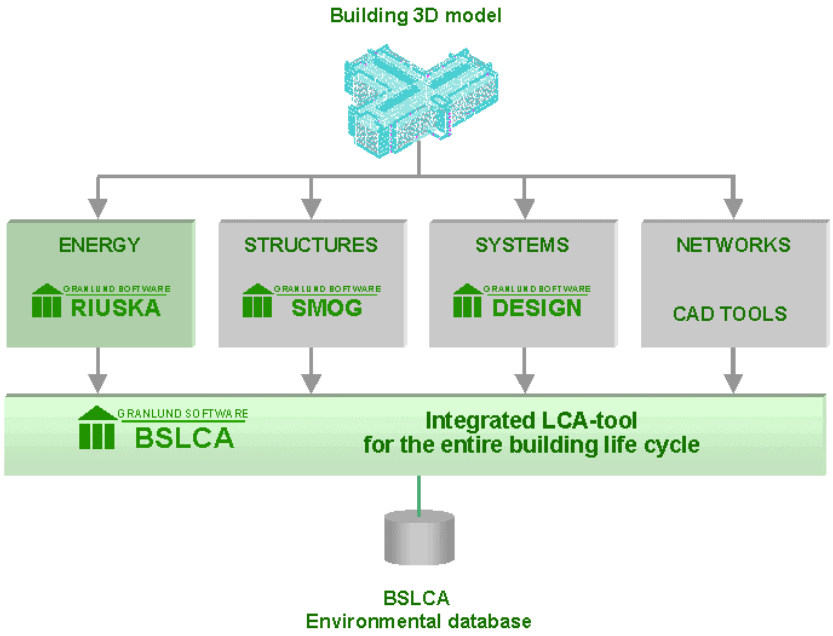

Figure 1 BSLCA is a tool for ecological design of buildings and systems with links to other software.

The use of IFCs facilitates importing of building geometry and structure related data from architectural CAD systems. If the architect is not using IFC compliant CAD software, the object oriented building 3D model can be produced by a special space modelling software SMOG and exported in IFC format.

The building services system design data is linked to the BSLCA tool by using compatible database structure. The system DESIGN tools cover the whole range of building services: HVAC, electrical and building automation. The building services networks are designed by using HVAC and electrical CAD software. Accurate information about ducting and piping quantities requires using 3D based HVAC CAD solutions with links to real product data.
The energy consumption is calculated by using Granlund's own RIUSKA, a dynamic simulation tool of comfort and energy consumption. RIUSKA utilises DOE2.1E software as a simulation engine.

Very little additional work is required for the LCA calculation itself as most of the information already exists through links to other design tools. The life cycle inventory (LCI) of building constructions and technical systems is very laborious if done manually. The integrated BSLCA-tool does this inventory quickly and produces both LCI and LCA.

The quantities and masses of the building envelope and the building service systems are linked from design data to the BSLCA tool. The designed objects are connected to actual products, designed structures to layers of building materials and energy consumption data to the database of different energy forms. The products in the library are named with actual type, model and manufacturer labels where the weight and material information is available from the manufacturer.

3.3 Calculation Principles

The default library values in the BSLCA tool include environmental profiles of different energy forms and different materials used in building service systems, this data has been published by VTT Building Technology or by the Helsinki University of Technology. The profiles are valid for materials produced in Finland and they include the manufacturing and transportation of the main components.

In the classification phase the inventory data is divided into impact categories. The calculation takes into account the emissions that have an impact on Global Warming, Acidification and Ozone Depletion and the corresponding weighting factors as given in the DAIA and Ecoindicator95 characterisation methods.

In the weighting phase of the Life Cycle Assessment the classified indicator values are combined to a total indicator value. The calculation tool uses DAIA and EPS methods for weighting but the software structure allows easy adding of new methods later.

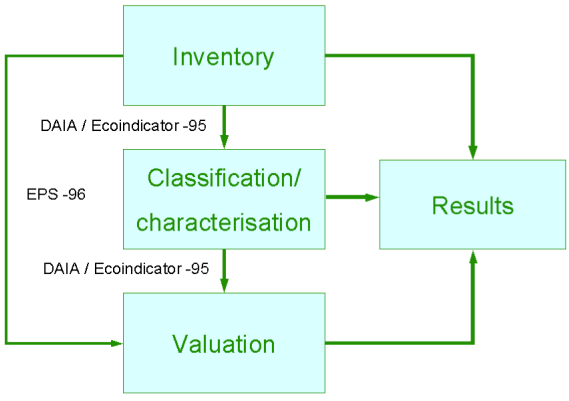

Figure 2 Characterising and/or weighting methods used in the BSLCA tool.

3.2 Outputs

The reporting from the BSLCA-tool is based on clear and simple comparisons. The user may navigate on different levels of the building hierarchy which makes it possible to analyse the ecological impacts of alternative design cases on different levels. This feature is unique for illustrating the things that are important – what is the meaning from the whole building and the whole life cycle point of view.

The BSLCA outputs the life cycle environmental emissions, characterised according to a chosen method. BSLCA gives the environmental profile of the building which is useful for the building owner in decision making at different stages of the building life cycle and also in steering the design and construction process towards sustainable solutions.

4. EXAMPLES

This chapter introduces some examples of life cycle calculations that have been made in projects to find the most ecological solutions.

4.1 Comparison of Window Size

The first example is from an elementary school building (17 000 m^3). In the design phase the effect of window size was analysed - the original window area was reduced by 10% (370 / 332 m^2) .

The LCA calculation takes into account the difference in materials (increased outer wall area, decreased window area) and an energy calculation was made to see the difference in heating energy. The building with the reduced window area has a heating energy consumption 3% lower than the original (26 kWh/m^3,a).

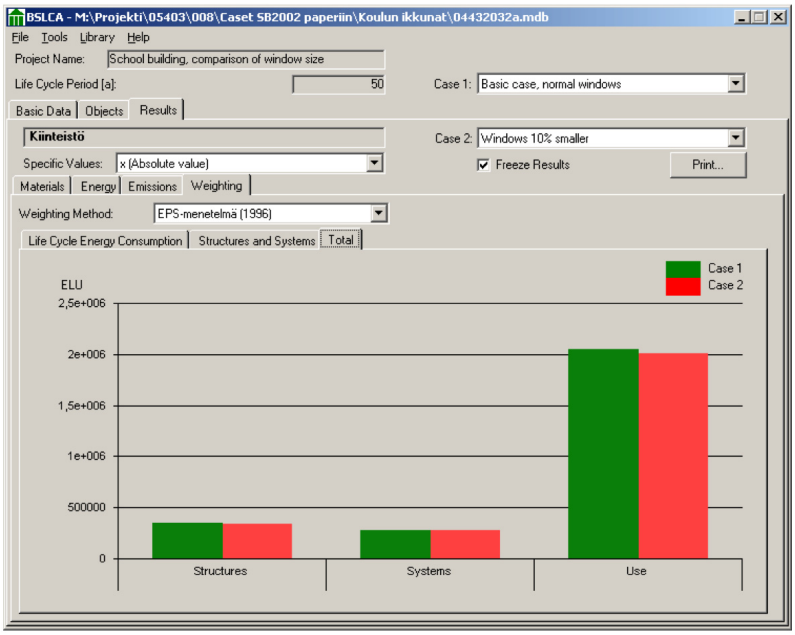

Figure 3 Comparison of window size shown on the Weighing-sheet of the BSLCA-tool results.

The total effect of the change in window size is a reduction of 200 tons in CO_2-emissions during the 50 year life cycle. The difference in EPS-weighted results is 42 000 ELU.

Some other aspects to consider in the decision making are: architectural image of the building, day-lighting in classrooms, construction costs, etc.

4.2 Comparison of Piping Materials

The second example is an office building (38 000 m^3) where different piping materials were compared. The basic design case includes water piping (cold and hot water) made of copper and sewage made of cast iron - a typical installation in Finland. A comparing calculation was

made using new composite piping (plastic with an aluminium layer) for water supply and PVC for sewage.

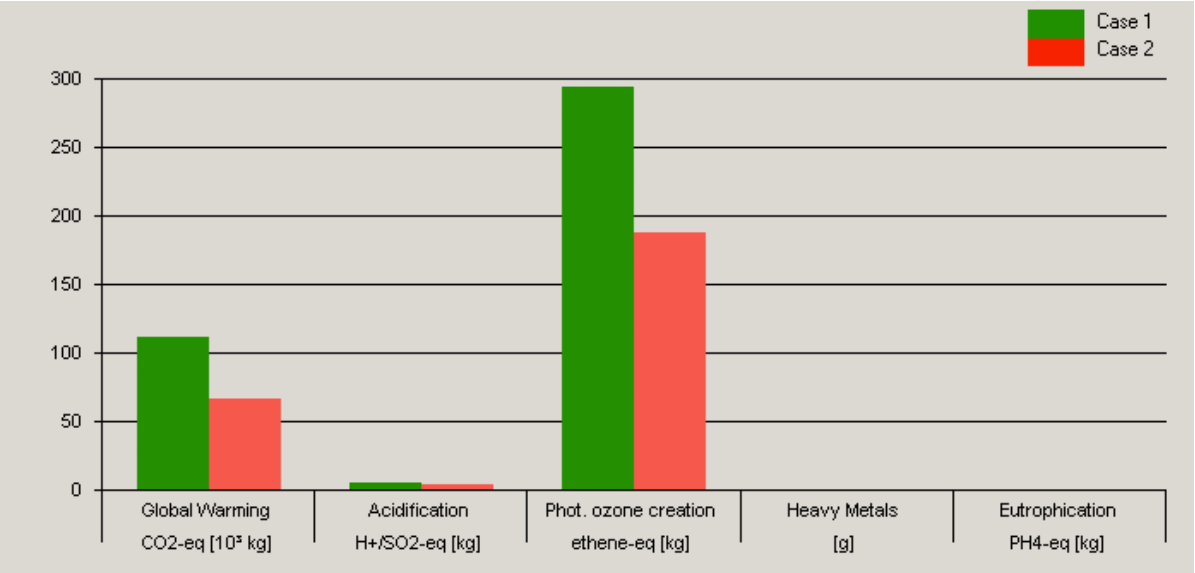

Figure 4 Comparison of piping materials, results on the Emisssions-sheet on the user interface of the BSLCA-tool.

The LCA calculation made at the water and sewage system level (not entire building level) shows a difference of 45 tons of CO_2-emissions for the life cycle of 50 years. The difference in EPS-weighted results is 19 000 ELU. The material saving is about 30 tons in cast iron, 1,3 tons in copper - the alternative causes an increase of 0,12 tons in aluminium and 1,9 tons in different types of plastic materials.

Some other aspects to consider in the decision making are: fire protection (need for additional insulation when using plastic piping), possibility of noise from sewers, installation costs, etc.

4.3 The Effect of Indoor Temperatures

The third example is a combined office and storage building (40 000 m^3). The building owner was interested in seeing the effects of operation and maintenance already in the design phase. Calculations were made using different occupancy hours, different room temperatures and different running hours for the air conditioning system.

The energy simulations show for example that

- an increase of 2 °C in the storage temperature during the heating season (19 > 21°C) leads to an increase of 6 % in heating energy consumption
- cutting one hour in the running schedule of the air handling unit (7-17 instead of 7-18) leads to reduction of 2 % in heating energy, 6 % in cooling energy and 9 % in fan electricity

The building owner can use these results for energy monitoring and when training the maintenance staff. The results make it easier to decide if the achieved energy saving is worth the risk of having complaints from indoor air quality.

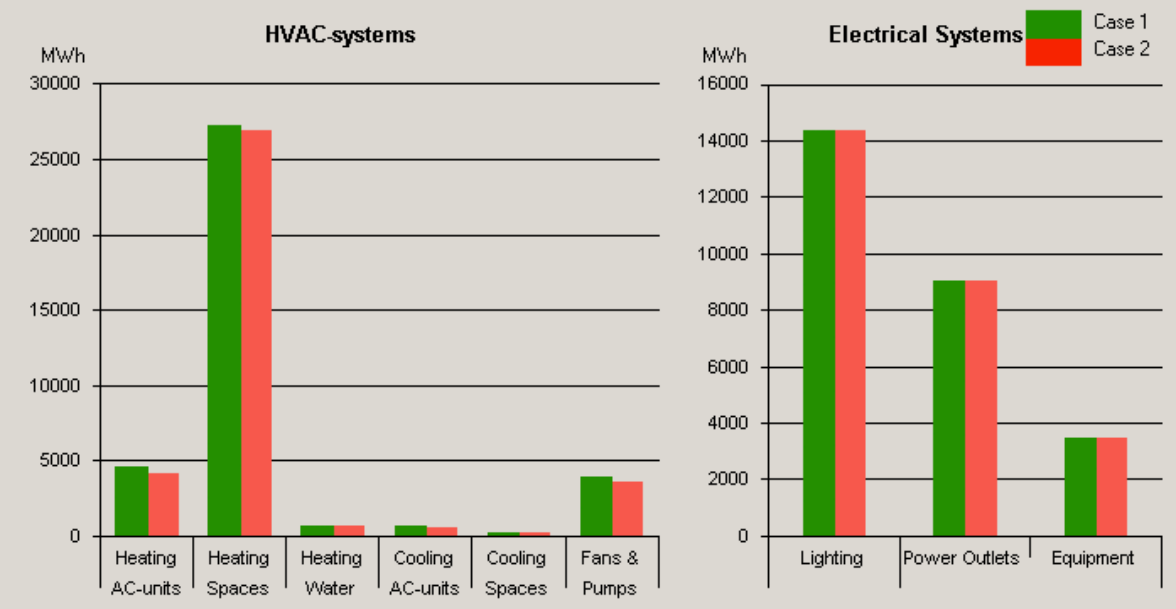

Figure 5 One hour difference in air handling unit's daily running time causes a remarkable difference on life-cycle energy.

5. CONCLUSIONS

BSLCA gives the environmental profile of the building and this profile shows clearly which alternative building parts or systems produce the most significant environmental loads. The profile is a useful tool for the building owner in decision making at different stages of the building life cycle and also in steering the design and construction process towards ecological and sustainable solutions.

Life Cycle based Procurement Method

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1. BACKGROUND FOR REQUESTING LIFE CYCLE TENDERS

Senate Properties is committed to sustainable development in all its activities. A central aspect of ecologically sustainable construction is the designing of the project, especially its technical systems and components, in such a way that not only the procurement costs but also life cycle costs are considered when making procurement decisions.

The Finnish Council of State has issued a decision in principle on promoting ecologically sustainable development in the real estate and construction sector, stating that all government organisations involved with developing must create their own programmes and procedures for ecological construction and property management, based on the example by Senate Properties. The Council of State decision in principle, for example, states that tenders for public procurement should include the ecological characteristics of the products and services, and defines the selection criteria.

To develop its own model for requesting life cycle tenders, Senate Properties has had its pilot project in the Finnish ProGresS programme – Profitable green development in real estate and construction business. The selected project was the extension of the National Bureau of Investigation (NBI) headquarters.

2. BASIC CASE INFORMATION

The NBI extension comprises 2,022 m2 of net floor area, 2,946 m2 of gross floor area, and 12,600 m3, and it had a budget of FIM 29.3 million. The extension includes two wings within the security walls of the old building. Designing the project was begun in December 1998, construction in April 1999 at the gas distribution room, and the building was handed over in July 2000.

The method chosen for this case was project management developing. Dividing contracts into several parts, this method is appropriate for life cycle tenders, because they are requested by the property developer itself.

The NBI headquarters is located in Tikkurila, Vantaa, in Jokiniemenkuja 4 (at the northern side of the Helsinki metropolitan area).

3. ITEMS SELECTED FOR LIFE CYCLE TENDERS

The items chosen to be included in the life cycle tenders are all clearly defined entities with easily distinguished selection criteria. These procurement items were selected for the tenders:

- lifts

- wood-framed windows
- flooring
- pumps
- lighting (offices)

3.1 Lifts

Enquiries for lifts were made at the implementation design stage in spring 1999, so that the space requirement of the selected type of lift (with/out a motor room) could be observed in the final plans.

The tender request documents defined, apart from the usual technical requirements and contract conditions, all criteria from supplier quality to the use, service and maintenance of the lifts affecting life cycle costs. The life cycle costs were assessed as follows:

- Is the lift overhead motor operated or without a motor room? The space requirement of the motor room was to be included in the tender. Space costs were estimated by the developer and included in the comparison.
- To assess the energy consumption of the lift, the suppliers were to disclose in their tenders the yearly consumption of their lift type, based on the number of starts. The suppliers were also requested to disclose parameters for the motor and gearing, and times for acceleration, deceleration and steady run, and the total time for all three. The calculations were to be based on these figures:
    - number of starts 40,000 per year
    - average lifting height 9.6 m
    - average load 180 kg

  The buyer assessed the costs for the total consumption estimated by the supplier, using 0.29 FIM/kWh as the price for electricity.
- Other maintenance costs (such as servicing or the effects on ventilation or heating) were ignored.

Life cycle estimates were based on a service life of 30 years, with a calculated interest rate of 4.9 %.

The effect of quality criteria was included by raising the estimated life cycle costs of the supplier with no points by 1 %, and by lowering the estimate for the supplier with maximum points by 1 %.

Tenders were requested from five companies, and submitted by four. Only two companies disclosed the requested environmental and maintenance information.

The chosen tender was the one with the lowest life cycle costs by the given criteria, not the lowest tender. The most notable difference between the tenders was in the space costs of the motor room. The chosen lift type is without a motor room, and its calculated space costs are 45,000 FIM lower than those of an overhead motor operated lift. Moreover, the estimated energy consumption of the chosen lift based on the given figures is smaller than that of the lift with a motor room of the lowest tender.

As a result we can say that this call for tenders was a success, although there were only two tenders with applicable life cycle cost estimates.

3.2 Wood-framed Windows

As soon as the designing began, suppliers of wood-framed windows were asked in advance if they were interested in submitting tenders based on life cycle costs and ecological issues. We wanted to find out how much the companies have invested in life cycle matters, and what is their view of life cycle tenders. The companies were asked the following questions:

- Is your company interested in submitting a tender based on life cycle characteristics?
- Does your product come with an official environmental account? If not, could you provide an informal one?
- Does your company have an environmental programme?

The companies were also asked to provide any additional product information.

The enquiry was sent to 72 companies, of which only one bothered to respond. And even this company did not have its environmental account quite finished. Afterwards we called a few companies and asked why they had not been interested to answer. The reply was in most cases simple: the companies lacked the resources for submitting a life cycle tender.

Based on these answers it was decided to give up calling for life cycle tenders for the wood-framed windows, and instead call for normal contract tenders. The chosen contractor was the one that had replied to the initial enquiry.

3.3 Flooring

Enquiries for flooring were made in summer 1999 well before the installation was scheduled to begin. The criteria for supplier selection were the life cycle costs and ecological characteristics of the material. The following factors were to be included in the life cycle cost calculations:

- material price exclusive of installation
- maintenance costs
- estimated installation costs

and these factors in the assessment of ecological characteristics (as specified in the tender request):

- energy and raw materials
- recyclability
- emissions, divided into indoor air emissions and those on a global scale

The estimated life cycle used for the calculations was to be 20 years, with an interest rate of 4.9 %.

The effect of the ecological characteristics was meant to be included by raising the estimated life cycle costs of the supplier with no points by 5 %, and by lowering the estimate for the supplier with maximum points by 5 %. Should the tender fail to provide information on a certain factor, the points for that factor would be 0.

Tenders were requested from seven suppliers of flooring, based on preliminary enquiries.

The enquiry for tenders showed that suppliers were either incapable or unwilling to provide the requested information (despite preliminary enquiries). Only the supplier with the lowest tender gave all the information. Other reports were either very incomplete or too disparate. There could be no life cycle cost comparison. The supplier with the lowest tender was chosen for the floorings.

3.4 Pumps

Tenders for single ME components, namely ventilation machinery, have previously been requested for a few projects for the University of Helsinki. For the purpose, with funding from TEKES (National Technology Agency), we developed a computer program which enabled the suppliers to include all the required factors in their calculations easily and thus make their tenders comparable.

Life cycle tenders are particularly useful when not only the procurement cost but also the energy consumption of a machine or system is considerable. In addition to ventilation machinery, such ME components include cooling equipment and pumps. Because of the size and schedule of the project and the risks in experimental procurement, the chosen item for life cycle tenders was pumps, of which there are 16 in this extension project. The number includes pumps for radiator network, underfloor heating, inlet air equipment, cooling, and ac heating network.

Based on preliminary study, there were over 30 parameters affecting the life cycle characteristics of a pump. The criteria can be divided into economic and qualitative factors. In practice, including all these factors would have meant creating a computer program similar to the one mentioned earlier.

Finally the factors to be included in the tender were reduced to the most essential: procurement costs, energy consumption at the pump operating point, and some quality and environmental criteria mostly concerning the manufacturer.

In the actual tender enquiry the pumps were considered ”black boxes,” whose technical details and optimisation were left to the supplier. Thus there were no restrictions to the pumps’ technical solutions, such as them being wet or dry, or their frequency converters. Changes in the instalment environment caused by technical differences were compensated as extra costs when necessary. The tender documents included forms that enabled information, such as the total efficiency quotients of the pumps, to be provided in a standard, comparable format.

Tenders were submitted by three known suppliers. The prices varied considerably, the highest tender being 46 % more than the lowest. When the above criteria were considered, however, the difference between the yearly costs of the best and worst offers was only 5 %, thus quite insignificant. This alone is reason enough to say that the life cycle tenders were a success, and that they affected the choosing of the pump supplier. When considered over a period of 15 years, procurement costs make up only 20...25 % of the total.

The results also show that the most significant pumps regarding the whole building are the largest, while the effect of the smallest pumps remains minimal. The total number of small pumps in our building stock, however, is rather large, so they do have national significance.

Pumps are operated at several different points, and in some cases never at the actual design point. This factor should receive more attention, and we should define the conditions that better relate to the actual operating situation, to be the basis for requesting tenders. Now for the operating point, we had to work with assumptions based on experience and estimates.

Points received for quality criteria did not change the suppliers' final standing. Because competition in life cycle costs was very close, the quality criteria might have made a difference. Therefore, quality criteria must only be used after careful consideration.

For this kind of procurement method to become more widely used, proper tools for calculation must first be developed, so that tenders could be optimised using a "tender generator" provided by the buyer. Thus the workload for a single project would not be too much. Another possible solution is the yearly procurement method, which would also need further developing to be applicable.

3.5 Lighting (Offices)

Objective for lighting the offices was to create good conditions for the eyes with a maximum installment power of 10 W/m2. Quality criteria for lighting, such as light source properties, glare prevention, lighting intensity, and luminance ratio were defined in the procurement programme. Life cycle cost calculations included the procurement cost of light fixtures and bulbs as fixed costs, and energy, bulb replacement, and service and maintenance as variable costs. Tenders were requested of eight companies, of which three submitted one. The lighting system with the lowest procurement costs was also the one with the lowest life cycle costs. Quality characteristics of the lighting were assessed using results from a computer program.

Requesting and processing life cycle tenders for lighting is very hard when there are several different types of rooms in the building. The furnishings, the wall and ceiling reflection qualities (colours), and the special modifications required by the function of each space, etc. should be known from the first stages of project design. If lighting and light fixtures are used as a decorative element affecting the atmosphere of a room, it is considerably more difficult to define project objectives. In this project the task was made simpler by choosing identical office spaces for the life cycle tender. The outcome was good, despite suppliers showing little interest in the tenders. The set objectives were met.

4. ASSESSMENT OF THE PROJECT AND FUTURE RECOMMENDATIONS

This pilot project requested life cycle tenders for a few isolated items only.

To sum up it can be said that different procurement items vary greatly in their potential for life cycle assessment. For procurement of lifts, pumps, and lighting it was possible to find a reasonable method of requesting life cycle tenders. As for window and flooring suppliers, only few companies had either the resources or will to respond to the request, and life cycle costs could not be included in the procurement decisions.

However, including life cycle costs in procurement decisions is a clear signal to suppliers to develop the life cycle characteristics and ecological properties of their products, and to define parameters for each product. It is also important for life cycle tenders that designers as well are able to calculate life cycle costs, which should be a part of the selection criteria even before the requesting of tenders. Life cycle tenders should become an important part of procurement processes, so that companies would really feel the need to improve the life cycle characteristics of their products.

Construction Management Model for Sustainable Kindergartens

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1. INTRODUCTION

PWD Construction Management is a division of the Helsinki City Public Works Department responsible for the property development of public buildings and similar premises in Helsinki.

PWD Construction Management has been a major pioneer in the development and introduction of the principles of ecological property development. Ecologically sustainable solutions are being sought for instance in day-care centre construction.

The City of Helsinki Public Works Department is in charge of the development project. The project is an important part of a large Finnish development programme named ProGresS - Profitable green development in real estate and construction business - co-ordinated by RAKLI.

2. BACKGROUND

The environment profiles of two existing day-care centres were taken as a starting point. These showed that most of the environmental loading of a day-care centre over its life cycle comes from heat and electricity consumption during use. The Merituuli day-care centre in Herttoniemi and the Kamomilla day-care centre in Viikki were selected as pilot projects. Merituuli was implemented following the normal procedure, and for Kamomilla 5 % extra funding was allocated for expenses caused by ecologically sound design work and construction.

3. OBJECTIVES

The following objectives were set for the day-care centres:

- Kamomilla energy consumption down 30% from the PWD normal level;
- Merituuli energy consumption down 10% from the PWD normal level;
- healthy indoor air quality (class S2, no air conditioning);
- environmentally sensitive architecture;
- mode of construction allowing for adaptability;
- design work taking maintenance issues into account;
- informing the users of the day-care centres and developing co-operation.

4. CASE STUDY: KAMOMILLA, INCORPORATING ENVIRONMENTAL OBJECTIVES INTO THE DESIGN

The Kamomilla day-care centre was built according to the PWD Construction Management´s ecological property development procedures. In practice, this meant combining the environment objectives set for the day-care centre with the design objectives, as well as keeping these under control throughout the project. Particular emphasis was placed on the 30% energy conservation objective and healthy indoor air quality.

4.1 Selection of designers

The designer was chosen on the basis of environmental expertise verified through references solicited before requests for tenders were sent out. Environmental issues were appended to the designer's task list, and the directive "Division of duties between designers in environmentally friendly design work" was added.

4.2 Design solutions

The environmental objectives manifest themselves in the design. The building´s simple form minimises the size of its outer shell. Orientation, terrain and planting were designed to protect the building. Using as much wood as possible reduced the environment loading stemming from materials. The structural frame is mostly of timber construction and there is much wood in the internal walls, the elevations and the interior fittings. The insulation is cellulose wool, a material that uses recycled paper and requires low energy consumption in the manufacturing process.

Insulation thickness in the walls and roof were increased. Windows with a better U value than normal were selected. The K value is 1.1 in metal-framed windows and 1.4 in wood-framed windows (with selective glass). The durability, recyclability and maintainability of materials were also considered. M1 class materials were used in the interior to ensure good indoor air quality.

The lighting was mostly implemented as ambient lighting with energy-efficient fluorescent tubes and mini-fluorescent tubes with electronic fittings. These reduce energy consumption by approximately 25% and also last longer. The lighting of group rooms and work rooms used constantly was designed so that the lights are governed by a motion sensor, switching on when someone enters a room and switching off when the room is empty. A light sensor governs indirect lighting in the hall and the lobby; the lights are automatically turned off when the outdoor daylight level is sufficient.

To conserve water, the day-care centre has dual-function WC cisterns and electronic taps that conserve water and improve hygiene. Water consumption in the kitchen is monitored separately. Cold storage appliances are located in the plant room to utilise surplus heat.

The day-care centre has so-colled demand ventilation. Air is distributed by room group and by room. The ventilation in the group rooms and workrooms is controlled according to the air´s carbon dioxide content. Fresh air enters the intake through a 'glass suction chamber' that also functions as a roof light, making use of solar energy. Further investments to achieve energy conservation and better indoor air quality were required for machinery with greater capacity, frequency converters for the supply and extraction machinery, separate ventilation ducts and air flow controllers for each room.

4.3 Contracting

The environmental objectives were transferred to the construction programme and the Appendix, Contract Limits, where requirements for the use of alternative materials and products and the contractor's responsibilities regarding to the maintenance manual were defined. The contractor was also required to draw up and comply with an environmental plan for the site.

5. LCC AND LCA CALCULATIONS

The economy of the design and the achievement of the objectives were ensured through life cycle cost calculations. The solutions chosen were not only environmentally friendly but also economical over a life cycle of 30 years at a 4 % interest rate. Day-care centres' environmental profiles were calculated taking into account emissions and weighted environmental impacts calculated according to various methods. At Merituuli an environmental assessment report (attached) was prepared, while at Kamomilla separate LCC calculations measuring the effects of six different savings measures were carried out; these are summarised in the attached appendix.

6. RESULTS

The day-care centre was completed in autumn 2001. Its energy consumption and the achievement of the environmental objectives set will continue to be closely monitored. Kamomilla's energy consumption (heating, electricity and water) is monitored monthly. CO_2 concentrations, temperatures and utilisation degree of inverters are also monitored in living areas.

Based on the results of LCC and LCA calculations made in conjunction with pilot projects in its own production, PWD Construction Management has adjusted its planning guidelines (rough dimensioning) to increase the life cycle economy of ventilation machines' dimensioning. This emphasises the importance of taking life cycle considerations into account already in the initial design phases. The space allocation must also be taken into account if cabinet driers provided with heating pumps are used instead of cabinet driers provided with conventional thermal resistances because they require more space.

A maintenance manual was drawn up to ensure correct maintenance and use. A staff training session is being planned on ecological construction and for issuing instructions on how to use the building. There are also plans to brief the children.

Development of ecological day-care centre construction will not end with Merituuli and Kamomilla. Design work on the Auringonkukka day-care centre in Viikki is already underway, and construction will begin in early 2002. The procedures are being applied to office construction and eventually to all construction.

The impact of this development is far-reaching. Systematic property development practices and clear calculations improve decision-makers´ abilities to use life cycle costs and environmental impact as the basis for decisions instead of investment costs alone. Here PWD Project Management and the City of Helsinki are setting the pace for the rest of the industry.

7. PROJECT PARTICIPANTS

Property developer	PWD Project Management
User	Social Welfare Department

Day-care centre Merituuli

Architects	Jukka Turtiainen Oy Architects
Mechanical design and life cycle calculations	JP-Talotekniikka Oy
Electrical Engineers	Lausamo Oy Engineering
Structural design	Suunnittelu-Suni Oy
Contractor	Rakennus Paaluharju Oy

Day-care centre Kamomilla

Architects	PWD Architecture Division
Mechanical Engineers	Hepacon Oy
Electrical Engineers	Delta Oy Electrical Engineering
Structural Engineers	Konstru Oy Engineering
Life cycle calculations	EVTEK Institute of Technology
Contractor	Seicon Oy

Environmental Assessment Report

CHILDREN'S DAY-CARE CENTRE MERITUULI

BASIC INFORMATION
Scope: 1,258 m² (gross area)
Volume: 6,300 m³ (estimate)
Calculation assessment period: 50 years

CONSUMPTION OF NATURAL RESOURCES

Consumption of raw materials
Energy consumption
Non-renewable resources: 90.4 10^6 MJ 71,900 MJ per m² (gross area)
Renewable resources: 8.5 10^6 MJ 8,500 MJ per m2 (gross area)

ENVIRONMENTAL IMPACT

Atmospheric warming: CO_2 equivalent 5, 921,000 kg 4,710 kg per m² (gross area)
Acidification: SO_2 equivalent 16,600 kg 13.2 kg per m² (gross area)
Formation of oxidants: C_2H_4 equivalent 9,570 kg 7.6 kg per m² (gross area)
Eutrophication: PO_4 equivalent 6,300 kg 5.0 kg per m² (gross area)
Suspended Particulate Matter emissions: SPM equivalent 22,100 kg 17.5 kg per m² (gross area)

INFORMATION ABOUT THE BUILDING

- The building is founded on concrete footings over sandy soil. The sub-floor construction consists of load-bearing hollow-core slabs with insulation above. The insulation is 200-mm polystyrene or mineral wool.
- The building's structural frame has been implemented with load-bearing exterior walls and steel columns. At the hall section the bearing construction is reinforced concrete cast in-situ.
- The building does not have a civil defence shelter.
- Approximately half the facades are burnt red brick. The rest of the exteriors consist of copper sheets and boarding.
- Windows are aluminium-surfaced wood windows provided with selective films.
- The roof is primarily a ridge roof with machine-jointed galvanised metal as the roofing material.
- Of the partition walls, approximately half are KAHI brick or burnt brick. The other half are metal-framed drywall partitions.
- Floor surfaces are primarily pine boards. Wet spaces are tiled, elsewhere plastic mat and parquet flooring.

CALCULATION PRECISION AND SOURCES OF INFORMATION

- The calculation's precision regarding the building terminology under consideration exceeds 95 %. The calculation has not taken furnishings' emissions into account; the assessment of mechanical, electrical and building automation components is based on previously completed projects.
- The building's environmental impacts have been calculated on the basis of the ISO 14040 Standard.
- The building's environmental impacts have been calculated on the basis of the Eco-indicator 95 method, a pan-European method used to calculate environmental impacts.
- Quantitative data used in calculations are based on PWD Construction Management's cost estimate furnished to the bill of quantities on 31 December 1999. Energy consumption figures are based on calculations for maintenance costs made by JP-Talotekniikka (6TL2401).
- Energy emissions are based on the Technical Research Centre of Finland's environmental profiles for Finland's average electrical consumption and Helsinki Energy's district heating consumption.

Implementing of Environmental Manual for Service Buildings

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1. INTRODUCTION

PWD Construction Management is a division of the Helsinki City Public Works Department and responsible for the property development of public buildings and similar premises in Helsinki.

The Helsinki City Real Estate Department is responsible for managing, renting and selling land and real estate owned by the City of Helsinki.

The City of Helsinki, Real Estate Department is a participant of a large Finnish development programme named ProGresS - Profitable green development in real estate and construction business - co-ordinated by RAKLI.

The co-operation between Real Estate Department and PWD Construction Management made it possible to do three environmental manuals to the service buildings.

- The Environmental Guide for Service Premises
- The Environmental Manual for Community Centres
- The Environmental Plan for Malmitalo Cultural Centre

The environmental effects of the city are great and so are its possibilities to influence the environment. The city of Helsinki is the largest single real estate owner in Finland. 13,8 million m^3 of the city-owned real estates are public service facilities. Conclusions can be drawn that together they can have a significant influence on the wellbeing of our environment and the saving of natural resources.

The most important environmental effects caused by service buildings (includes schools, kindergartens, healthy centres, hospitals, libraries, multipurpose buildings etc.) originate of use of land, energy management, solid waste management, solid waste management and the long-term durability of materials and supplies used. Educating and motivating personnel and clients in measures in connection with ecologically sustainable real estate maintenance and facility management, and handing out instructions for this purpose, decrease environmental effects and life cycle costs.

2. OBJECTIVES

When commencing environmental management in service facilities, it is important to resolve initial levels of and to set aims and means of measuring consumption and emissions, as well as assigning tasks and defining schedules thereof. The success of an environmental plan is dependent on the tenant of the commitment.

In the long run, environmentally sound activities are always beneficial for the whole economy. In many occasions, an environmentally good choice results in cost efficiency through, e.g., energy costs.

The general environmental goal affecting the maintenance and management of real estate owned by the city of Helsinki, still is to develop co-operation between different parties in environmental matters by creating rules and responsibilities for different parties and by creating consistent real estate maintenance and management instructions for the whole city, for example in the form of guidebooks.

The goal of the environmental guide for service premises is to further the realisation of environment protection and sustainable development in the use and maintenance of real estates, so that it will result in a healthy, safe and comfortable environment inside and outside the building, for the users as well as visiting clients to enjoy.

3. ENVIRONMENTAL GUIDE FOR SERVICE PREMISES

By signing the Declaration of European Cities and Towns working towards sustainability (known as the Aalborg Declaration or the Aalborg Charter) in February 1995, the City of Helsinki made a commitment to develop its activities in an ecologically, economically and socially sustainable direction. A start was made on implementing the goals of the Declaration by launching a local Agenda 21 process, which led to an environmental policy being drawn up for the City, and each of the various City organization setting to work on improving environmental issues in their own particular field.

One concrete example of the progress of the local Agenda 21 process is the environmental guide drawn up for service premises at the initiative of the City Real Estate Department. The guide is aimed at the users of such premises and its intention is to reduce environmental loading over the whole life cycle of the premises. Service premises owned by the City include schools, day centres, health centres, sports facilities, libraries and various office and commercial premises.

The guide contains background information on environmental issues, a review of environmental aspects associated with service premises, plus a model and instructions for drawing up an environmental plan for the individual premises concerned. The environmental guide for service premises has also been adapted for multi-purpose buildings, in a form that highlights the clearest possible operating instructions for using multi-purpose buildings in an environmentally friendly way.

The work on drawing up the guide did not slide into theoretical deskwork; instead Malmitalo, which acts as a cultural centre for the northern and northeastern parts of Helsinki, was used as a pilot project. Development work on an environmental plan for Malmitalo began by charting the current state of environmental issues, and then proposals for improvements were added to the operating instructions. The experience gained from the pilot project was fed back into the general guide which can clearly be seen in its practical and encouraging approach.

4. PROJECT PARTICIPANTS

Malmitalo management and staff
The City of Helsinki Real Estate Department
The City of Helsinki Public Works Department
Turku Polytechnic, sustainable development training programme

Life Cycle Competition for Heat, Ventilation, Air-condition and Plumbing System

Aimo Hämäläinen, Technical Manager[1]
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LIFE CYCLE TENDERS FOR SUSTAINABLE DEVELOPMENT

The University of Helsinki uses some 400 buildings (floor area 650,000 m^2). These include lecture theatres, auditoria, laboratory and research facilities, libraries, student and staff canteens, and office space.

The University of Helsinki has committed itself to environmental friendliness across the board in its sustainable development programme. The energy consumption of buildings and emissions caused thereby constitute one of the University's most significant environmental impacts. Energy consumption can be influenced through technical decisions taken at the investment stage and through maintenance and use procedures. The finding of new solutions that are economical and environmentally friendly from the life cycle point of view has required the evolution of procedures related to property development, maintenance and use. In this, the University has done pioneering work in Finland.

The University of Helsinki has an aim to develop a suitable procurement method for life cycle competition according to the design-build principles. The circle form of the building and double-glazed facade offered an interesting solution especially for developing ventilation system.

The competition was conducted in two stages. On the first stage, the candidates proposed their ideas for a solution and the finalist were chosen. On the second stage the finalists gave their final tenders with complete engineering solutions. The tender evaluation was based on the life-cycle-cost-calculations. The current value of the heating energy and power, the maintenance, and the repair costs were added to the price of the tendered HVAC and plumbing system. The maintenance responsibility for a five year period (also for maintenance costs) was included in the contract.

CASE STUDY: VIIKKI INFOCENTRE, COMBINING DESIGN AND MAINTENANCE RESPONSIBILITY IN A LIFE CYCLE BID

The life cycle tendering procedure was developed in the Viikki Infocentre project, where it was first applied. The life cycle tender involves a competitive tendering procedure for a contract that includes both design and responsibility for maintenance.

In the case of the Viikki Infocentre, the life cycle tender applied to the mechanical services installations; *the tenderer undertook maintenance responsibility for a period of five years,*

including liability for energy consumption in excess of the goals set, plus care, maintenance and repair costs. On the basis of innovative system planning and life cycle costs, Putkiura Oy was selected as the mechanical and automation services supplier and Climaconsult Finland Oy as the designer of the systems.

The life cycle tender procedure produced an excellent result. *The building's heat consumption is 13 kWh/a/m^3, or about a quarter of the normal figure for a comparable building*. This has been achieved with a level of design representing normal good quality. The electricity consumption is 18 kWh/a/m^3, which is also reasonably good considering the rate of use of the building (60 h per week) and the amount of computer technology housed in the building.

Also indoor air quality is excellent. *Measured levels of Co2 have been between 400-600 ppm everywhere in the building. The limit of the best class is under 700 ppm based on the classification of The Finnish Association of Indoor Air*. Measured total contents of particles have been great, under 10 μg/m^3. (The limit of excellence is PM10 < 20 μg/m^3).

The technical design features that contributed to energy conservation are:
- the circular shape of the building, minimizing the area of the external walls;
- double skin, enabling warming of supply air, night cooling during the air conditioning period and minimizing heat loss;
- facilities for air intake from the north or south side, according to air temperature;
- efficient heat recovery;
- ventilation system guidance according to use and use periods;
- energy-consuming items/locations can be separately measured;
- continuous monitoring of energy consumption from a remote control room (forthcoming).

Eco-technical tasks of the swerving glass wall:
Decreases temperature loss in the winter and the need for cooling in the summer
Fresh air for the air conditioning system is taken from different sectors during different seasons

CASE STUDY: BIOCENTRE 3, ADAPTABILITY THROUGH A "SHELL AND CORE" SOLUTION

The development begun with the Infocentre was continued in Biocentre 3, which mainly houses laboratories and classrooms. The goal set for the building's heat consumption was 30 kWh/a/m^3. The tenders received through the life cycle tender procedure were evaluated with an impartial life cycle calculation (Riuska program, Olof Granlund Oy engineers). Koja Oy was selected as the supplier responsible for design, implementation and maintenance, and Niemi Oy engineers were selected as the designer.

In addition to energy efficiency, one of the objectives was adaptability through a *'shell and core' design, where the frame of the building and its technical infrastructure are implemented as separate and independent systems.* In practice, this means that the technical installations are housed in separate ducts and conduits with ample space allowing for alterations and repairs without having to penetrate the structure of the building. Adaptability was also applied to the rooms, with all connections designed so that any alterations can be carried out on a room-by-room basis.

Energy efficiency was enhanced by making use of the building's free heat sources and cooling devices in the heating and cooling systems; for example, process heat and extract air

are used in the ventilation pre-heating system. The ventilation system has two sets of machinery, with only one set operative at night. The technical systems can be easily controlled and monitored in all laboratory facilities.

The University development work continues. The next project scheduled is the new building for the department of veterinary and food sciences, where building services integration in the structure of the building will be further explored. This means that water pipes, drainage and ventilation ducts will be fitted into hollow-core slabs.

For this design to succeed it is essential that all parties commit themselves to a specific goal. The tender procedure the Helsinki University have developed provides the motivation for this.

One motivator has also been a Finnish development programme named ProGresS - Profitable green development in real estate and construction business - co-ordinated by RAKLI, in which The Helsinki University has been one of the key participants.

Project participants:

Viikki Infocentre
Putkiura Oy, building services system supplier
Climaconsult Ltd, building services design

Biocentre 3
Koja Oy, building services system supplier
Niemi & Co Oy, Engineers, building services design
Olof Granlund Oy, Engineers, life cycle calculations

Using Energy Life Cycle Costs as an Instrument for Optimisation

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1. INTRODUCTION

Sustainability is often formulated in absolute terms: eliminate as much environmental load as possible. Such attitude may generate exploding investment costs. As investment reflects the efforts a society has to last to gain a benefit, it must be clear that elimination is not an affordable objective. Much better is to strive for optimisation, i.e. to search for a minimum in life cycle costs. In case energy consumption in buildings and related greenhouse gas emissions act as the load, the life cycle costs are easily calculated in terms of a net present value (NPV) (Werner, 1988, Rudbeck, 1999):

$$NPV = I_o + \sum_{j=x,y,z}\left[\frac{I(1+r_I)^j}{(1+a)^j}\right] + \sum_{i=1}^{n}\left[\frac{K_E(1+r_E)^i}{(1+a)^i}\right] + \sum_{i=1}^{n}\left[\frac{K_M(1+r_M)^i}{(1+a)^i}\right] \qquad (1)$$

with I_o the initial investment, I additional investments needed after x,y or z years, K_E the annual energy cost, K_M the annual maintenance cost, r_I the inflation cleared annual increase in investment costs, r_E the inflation cleared average annual increase in energy costs, r_I the inflation cleared average annual increase in maintenance costs, a the inflation cleared actualisation factor and n the time window in years. All factors in (1) are random in nature. Investments depend on demand and offer at the particular moment. Future investments may relate to better technologies whose costs are actually unknown. Energy prices fluctuate depending on the geopolitical scene and demand and offer. Maintenance costs also reflect the market. The risk on unsatisfactory return shapes the actualisation factor. If high, human reaction is to strive for a quick return, which means a high value. If low, a moderate actualisation factor is accepted.

Buildings are a specific case. As long lasting goods, the time window for return is more or less fixed: between 30 years, representing a one generation habitation, and 80 years, the average service life. This explains why a moderate actualisation factor, between 0 and 5%, coupled to a long time window satisfies human expectations quite well.

2. NET PRESENT VALUE AS AN INSTRUMENT FOR OPTIMISATION

Optimisation presumes formula (1) to be usable as a fitness function. Therefore the formula should contain one or several independent variables. That being the case, is easily proven on

the level of a flat building component, where the thermal resistance R_{is} of the insulation layer acts as independent variable (Erlandsson, 1997). The investment and annual energy costs are then given by:

$$I = A_o + b_o R_{is} \qquad K_E = \frac{b_E}{R_o + R_{is}} \qquad (2)(3)$$

with A_o the cost of the non-insulated component included the labour term in the insulation cost,, b_o the insulation cost per unit of thermal resistance, R_o the thermal resistance of the non-insulated component and b_E the annual energy cost in case $R_o+R_{is}=1$. The net present value for r_E constant, r_I constant and a constant in turn is given by:

$$NPV = A_o + b_o + C_{NPV} \frac{b_E}{R_o + R_{is}} \qquad (4)$$

with C_{NPV} a function of a and r_E. Optimum insulation thickness:

$$\frac{dNPV}{dR_{is}} = b_o - \frac{C_{NPV} b_E}{(R_o + R_{is})^2} = 0 \quad \text{or} \quad R_{is} = \sqrt{\frac{C_{NPV} b_E}{b_o}} - R_o \qquad (5)$$

Figure 1 shows a result for a cavity wall with a mineral fibre fill. Constants: b_o= € 3.38/(m².W/K), b_E= € 3.46/a (transmission loss only, Ukkel reference year, south orientation, 18°C inside, hydronic central heating, natural gas at € 0.029/kWh, system efficiency 62%, actualisation factor 5%, annual increase in energy cost: 2%), A_o= € 3.59 (insulation only) and R_o=0.77 m².K/W. The NPV-optimum touches R_{is}=4 m².K/W, while the highest return in terms of lowest NPV per avoided ton of CO_2 is reached at R between 4 and 6 m².K/W.

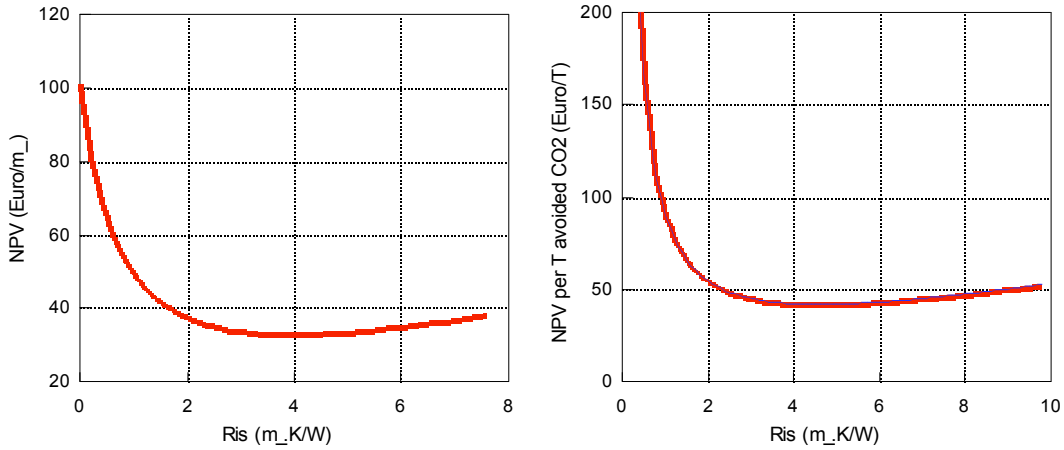

Figure 1 Fully filled cavity wall, looking for the optimal thermal resistance of the mineral fibre fill, at the left side in terms of a minimum NPV, at the right side in terms of a maximum rentability (minimum NPV per avoided ton of CO_2 over the time window).

Stepping from 1 m² of envelope to a whole building of course complicates the scene. Not one, but five different envelope surfaces have to be optimised now: pitched roofs, flat roofs, the opaque facade walls, the windows and the floors. Especially changes in glazing, not only impacts the transmission loss but also the solar gains. In case the heating system is an invariant, also the system's efficiency changes with the thermal performance of the building. Individual

thermal resistance's are also no longer usable as optimisation indicator. It is better to switch to the average thermal resistance of the envelope.

In terms of the first investment, insulating a building not only induces first order costs, expressed by the sum of an R_{is}-independent term, which changes with the number of insulation layers used, and an R_{is}-dependent term (see formula (2)), but also generates second order costs. Opaque walls become thicker. This enlarges the floor surface or diminishes the building's net surface. In both cases, second order costs appear. A larger floor surface means additional foundation, floor and roof construction. Less net surface in turn lowers users satisfaction, a cost again. A thicker wall also impacts foundation width, window reveal width and roof edge detailing. Also the heating system is impacted. The better in fact the thermal performance of the building, the smaller the system needed and the lower its cost. The relationship however is not linear as boiler capacity, piping diameters and radiator capacity offered does not vary continuously. For the exercise ahead, the heating system was kept invariant.

Durability of the measures taken defines maintenance and future investments costs. Wall, floor and pitched roof insulation may last maintenance-free as long as the building exists. Flat roof insulation instead is more vulnerable as leakage risk is quite high. Double glass systems, however, are the most vulnerable part. On average, a service life of 25 years is a good guess.

Energy costs not only depend on weather, building and heating system parameters but also on users behaviour. For the user energy services, such as thermal comfort, are the key concern. If energy consumption is too expensive for the comfort wished, he tends to accept a lower comfort level. That is called the rebound effect. Hens et al, 1993, gave results of an inverse analysis, calculating the average inside temperature that explained the energy consumption measured in 52 dwellings. They found as a relationship (r^2=0.34, $\sigma_{15.7}$=1.9, $\sigma_{0.00235}$=0.00087):

$$\overline{\theta}_i = 15.7 - 0.00235 H_T \tag{6}$$

with H_T the specific transmission loss. Physics explained part of that relation. People in fact hardly heat the sleeping rooms. The other part however reflected the rebound effect.

A simple energy tool such as those based on degree days are not fit to account for these influences. Therefore, a better model, called Verbruik 2.x (Ali Mohamed et al, 2001), was developed based on the EN 832 (Anon, 1998), with addition of a rebound module, a heating system module, a hot water module and a lighting and appliances module. The tool calculates energy consumption on a monthly mean basis and adds the monthly results to get the annual total. Version 2.2 of the model contains a batch sub that activates the energy, cost and fitness functions automatically for successive steps in insulation performance. Each envelope part starts at an insulation thickness zero. The batch sub then increases the thickness in a series of stepwise loops on all five parts and calculates total energy consumption over the time window of 30 or 80 years and the change in embodied energy by the better insulation. Finally NPV and CO_2 released are quantified.

3. APPLYING THE METHODOLOGY ON A DETACHED NEW HOUSE

3.1 Insulation thickness, investments and costs

Table 1 gives all information on insulation thickness and its stepwise increase for flat roofs, pitched roofs, walls and floors. Table 2 mentions the insulation costs. The extra costs for glazing, compared with a single pane (prices 1998) are: double 16.96 €/m², triple 33.91 €/m², low

e air-filled 49.58 €/m², low e argon-filled 61.58 €/m², low e krypton-filled 73.97 €/m², U=0.6 W/(m².K) glazing 98.76 €/m². The replacement after 25 years not only mobilises the full glazing cost but also additional labour costs. Therefore a future investment in the extra glass cost plus 38.48 €/m² is included each 25 years.

Table 1 Insulation thickness

Envelope part	Min. insulation thickness m	Max. insulation thicknes m	Stepwise increase m
Flat roofs	0	0.24	0.04
Pitched roofs	0	0.24	0.04
Facade, insulation	0	0.16	0.04
Floors	0	0.12	0.04

Table 2 Insulation costs (prices 1998-1999)

Envelope part	Insulation material	Maximum board thickness m	Costs per m^3 €/m^3	Mounting €/m²
Flat roofs	Mineral fibre	12	295.69	25.41
	PU-foam	10	203.27	(included
	Cellular glass	12	391.05	vapour barrier)
Pitched roofs	Mineral fibre	7.5	84.41	9.05
	Cellulose	50	84.41	(included
	Expanded PS	12	163.61	air barrier)
	Extruded PS	16	281.28	
Facade, insulation	Expanded PS	12	163.61	3.59 per
	Extruded PS	16	281.28	layer
	Mineral fibre	7.5	84.41	
Floors	Expanded PS	12	163.61	3.59 per
	Extruded PS	16	281.28	layer

All prices are averages without TAV (21% in Belgium). The second order costs per m window reveal are: $I = \mathrm{Max}\left[0, 61.48\sqrt{A_w}\left(d_{is} - d_o\right)\right]$. Per m² additional floor and roof surface they reach: $I = \mathrm{Max}\left[0, 173.03 P_{floor}\left(d_{is} - d_o\right)\right]$, both in €. In the two expressions, A_w is the widow area, P_{floor} the floor perimeter, d_{is} the insulation thickness and d_o a reference insulation thickness, which accounts for a traditional cavity width of 6 cm. d_o is set 0.03 m for a partial and 6 cm for a full fill. Energy prices TAV included: oil 0.16 €/l, gas 0.23 €/m^3, electricity (a mix of day and night) 0.11 €/kWh. Also these prices refer to 1998-1999. In 2000 for example, oil doubled! The actualisation factor used is 5%, r_I is taken zero and the energy prices are kept constant over time. A most conservative assumption of course Time window: 30 and 80 years.

3.2 Basic data

The detached house is a two stories quadratic construction in load bearing brickwork with concrete floors and a hipped pitched roof covered with tiles. Its heated volume (V) is 980.4 m^3 for an enclosing surface (A_T) of 890.8 m², i.e. a compactness (C) 1.1 m ($C=V/A_T$). The house has a hydronic central heating with a high efficiency boiler on constant water tempera-

ture, radiators, a room thermostat and hot water on the boiler. The monthly mean inside temperature with the rebound effect included is defined as

$$\overline{\theta}_i = \mathrm{Max}\left(15.7 + 0.27\overline{\theta}_e, 15.7 - 0.00435 * \left(U_m A_T - 1000\right) + 0.27\overline{\theta}_e\right) \quad (7)$$

where $\overline{\theta}_e$ is the monthly mean outside temperature of the TRY-year for Ukkel, Belgium. Additional characteristics of the non-insulated base case are given in table 3. Table 4 summarises the energy performances: mean U-value, heat demand, annual energy demand for heating, annual end energy consumption and CO_2 released. Clearly, all values are unacceptably high.

Table 3 House characteristics

Envelope part	Surface m²	Base U-value W/(m².K)	g-value -
Pitched roofs	240.2	1.64	
Cavity walls	391.2	1.41	
Floors	207.7	1.94	
Windows	51.7	5.44	0.77-0.8

Table 4 Base case, energy and environmental performance

Mean U W/(m².K)	Heat demand W	Energy demand for heating MJ/a	End energy consumption MJ/a	CO_2-release kg/a
1.67	54 600	235 100	367 700	20 180

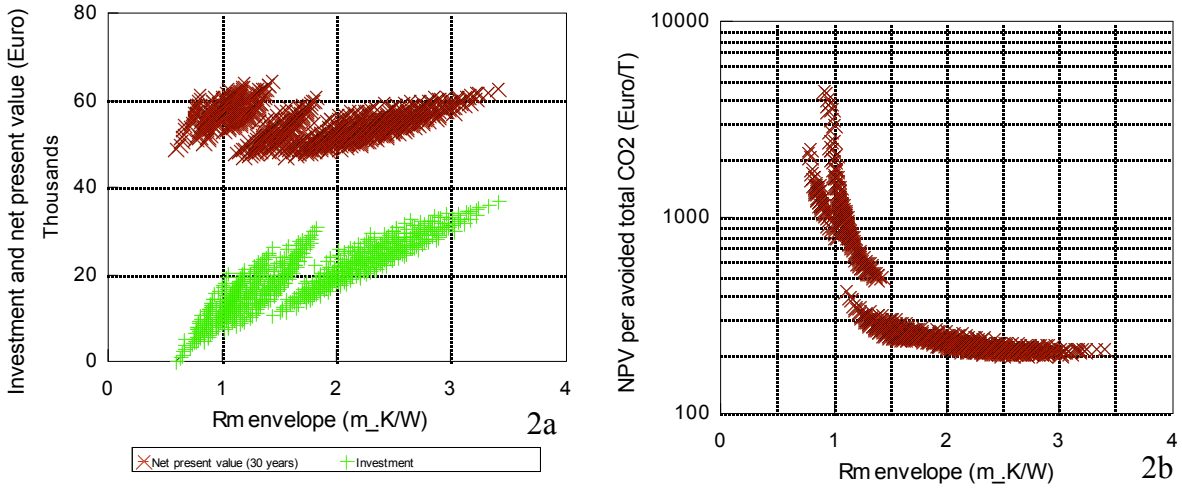

Figure 2 Detached house. Optimisation results. Total investment and total net present value over a period of 30 years (2a). Net present value per total avoided CO_2 over 30 years (2b)

3.3 Optimisation results

A total of 980 runs were achieved. Each run saw the insulation thickness in one of the envelope parts increased compared to the previous one. In all runs, the change in embodied energy was a very small fraction of the energy consumed. Some other results are summarised in figure 2. 2a suggests that the NPV over 30 years touches a minimum for an average envelope thermal resistance (R_m) close to 1.5 m².K/W. Since the curve is so smooth, it anyhow seems better to consider an interval of optimums with R_m=2.1 m².K/W as upper limit. The average

envelope thermal resistance which gives the highest return, i.e. the minimum NPV per total amount of avoided CO_2, included the embodied part, lays between 2.5 to 3 m².K/W, see 2b. The results of course are very sensitive to changes in parameter values (r_E, r_I, r_M, a). For an r_E of 2% instead of 0, both optima shift to higher R_m's. A more extended study learned that a R_m up to 2.3 m².K/W minimised NPV, while $R_m \approx 2.7$ to 3.9 m².K/W resulted in the highest return.

4. CONCLUSION

The paper proposes a net present value approach (NPV) to analyse the energy life cycle costs of buildings and uses NPV as fitness function for insulation optimisation at the building level. Although at that level an analytical solution of the fitness function is no longer possible, a numerical approach works quite well. It allows among others to include the overall complex reality with second order costs, a rebound effect, the balance between heat loss and heat gain, the impact of thermal performance of the envelope on the heating efficiency, future investments and maintenance costs.

Optimisation learns that thermal insulation acts as an effective measure to minimise the net present value and to realise a highest return in terms of a minimum NPV per avoided ton of CO_2 during the time window considered. The distance between the actual legal requirements on the average thermal resistance of the envelope (R_m) in Belgium and the optimal values predicted that way anyhow is striking. The minimum R_m imposed depends on the compactness ($C=V/A_T$ with V the heated volume and A_T the enclosing surface). If C is below 1 m, R_m=1.8 m².K/W should be realised. For C above 4 m, R_m=0.9 m².K/W is the minimum. In between 1 and 4, a linear relationship between R_m and C must be applied: R_m=2.1-0.3C. If the lowest return R_m should be imposed for new construction, CO_2 emissions in the residential sector may diminish in 2012, compared to 1990, with a percentage ranging from 1.4 to 23.8%. Where in between both limits important depends on housing policy and sociological evolutions (Ali Mohamed et al., 2001).

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Promotion of corporation's energy efficiency and developing a tracking system

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INTRODUCTION

This paper focus on voluntary energy conservation agreement. It is a Finnish way to answer to the challenges of energy efficiency in corporations' property portfolio.

1. KRESS — VOLUNTARY ENERGY CONSERVATION AGREEMENT FOR THE PROPERTY AND CONSTRUCTION SECTOR

KRESS, the voluntary energy conservation agreement for the property and construction sector is based on a joint agreement to promote energy efficiency in the property and construction sector signed by the Ministry of Trade and Industry and RAKLI, the Finnish Association of Building Owners and Construction Clients, in 1999. The agreement is aimed at RAKLI member companies except for industry, government property units and local authorities.

1.1 Key element of a company's environmental management system

Energy-efficient operating models and tools that can be applied to the property business are being developed within the framework of the agreement. *The measures and operating models contained within KRESS form a key element of a company's environmental management system*.

1.2 Target to cut heating energy consumption by a systematic model

The numerical targets in the KRESS agreement are *to cut specific heating energy consumption by 10% from 1998 levels by 2005 and 15% by 2010.* As far as electricity is concerned, the aim is to halt growth in consumption and force it into a decline by 2005.
Additional aims of the agreement include carrying out energy audits and introducing systematic consumption monitoring in 80% of the building stock within the agreement by 2005. Reaching a 50% level has been defined as an intermediate goal for 2002.

Targets set by individual companies can, in principle, vary according to the company's own wishes. Monitoring produces direct comparisons for company use. KRESS provides companies with the framework for a systematic and shared operating model for managing the energy use of their property portfolio. The tracking system provides energy efficiency information yearly at building portfolio level.

To the end of March 2002, 21 companies have joined the agreement, and the property they own or manage corresponds to approximately 75% of the total property portfolio of the companies in the sector covered by the agreement. Nevertheless new companies are still being encouraged to join KRESS.

1.3 Case study: Antilooppi, systematic energy efficiency produces savings and boosts image

Antilooppi Ltd forms an essential part of the property investment and management approach of the Ilmarinen Mutual Pension Insurance Company. Antilooppi Ltd is owned by Ilmarinen and is responsible for managing property worth 2.2 billion euros, including retail and office premises as well as distribution and warehousing premises. Antilooppi's management responsibilities also include matters related to the KRESS energy conservation agreement.

"The energy conservation agreement is not only an expression of will and a method of producing actual savings and corporate image benefits, but also a way of supporting energy-saving investments and reviews. An energy-monitoring system is necessary for optimizing maintenance costs, and the energy-saving agreement provides a systematic way of coordinating the work and motivating the staff," explains Antilooppi's regional manager.

Antilooppi plans to carry out energy audits on 70 properties with a total volume of about 2.5 million m^3 in 2002-2003, with a view to saving EUR 420 000. Surveys of condition will also be carried out on the properties in conjunction with the energy audits, as required.

Most of the potential savings are associated with building use, for example, optimizing the operation times and control parameters of air conditioning and ventilation. The efficiency of M&E services could be improved by using heat-recovery systems, but this requires investment. *Antilooppi's savings target is 10% of heat consumption and 5% of both water and electricity consumption by the end of 2010*. Using the monitoring system developed in conjunction with service providers, consumption targets can be tracked right down to the janitor level.

At Antilooppi, energy saving is linked firmly with environmental issues. In surveys of condition and reporting, waste accounting and environmental assessment can be taken into consideration as well as energy and water accounting.

1.4 Corporations in KRESS

Property owners that had joined the voluntary energy conservation agreement by the end of March 2001:

Sampo Group/ Kiinteistövarma Ltd
S Group/ SOK Kiinteistötoiminnot
Tapiola Group
Kesko Corporation/ Kiinteistökesko
Castrum Ltd
Fujitsu Invia Finland
Polar Real Estate Plc
Kapiteeli Ltd

Ilmarinen Mutual Pension Insurance Company/ Antilooppi Ltd
Fennia Group/ Kiinteistö-Fennia Ltd
Nordea Finland
OKO Bank Group/ OKO pension fund and OKO pension foundation
Pohjola Group
Suomi Group/ Suomi Insurance Company
Teljäntori Ltd
Finland Post Corporation
YLE - Finnish Broadcasting Company
Citycon Plc
Rinnekoti foundation
Arwidson Ltd
Savonlinnan linja-autoasema Ltd

Identification of PCB and decontamination of PCB-containing buildings in Norway

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1. INTRODUCTION

In Norway the first regulations for Polychlorinated Biphenyl (PCB) compounds were promulgated in 1980 and revised in 2000. In the last couple of years much attention has been paid to the presence of PCB and its potential impact on health and the environment. A national action plan for building and construction waste was introduced in Norway in February 2001 and one of its main efforts has been to focus on PCB in buildings and building materials.

On the initiative of the Federation of the Norwegian Construction Industry (Byggenæringens Landsforening (BNL)) a Guide containing information about the identification of PCB and the decontamination of buildings and building materials containing PCB has been prepared. The two consulting engineering companies, Techno Consult AS (Norway) and DEMEX Consulting Engineers A/S (Denmark), have participated in the preparation of the Guide, which was issued in December 2001.

2. THE PCB GUIDE

The aim of the Guide has been to collect and communicate existing information about PCB in buildings and building materials. The idea was to create a book of guidelines in a popular language and format. The Guide is primarily aimed at decision-makers, such as owners of buildings. Secondly, much of the information, especially that concerning the practical management/handling of buildings containing PCB, can also be relevant to other parties in the housing and building industry, for example consultants.

The Guide includes aspects such as:

- Criteria for the approval of buildings in relation to PCB
- Descriptions of sampling and methods for analysing samples
- Actual methods for removal or decontamination
- Alternatives for packaging, transport and places of delivery
- Existing knowledge about PCB and industrial relations
- How to describe removal/decontamination in tenders etc.

The figure below gives an overview of the remaining amounts of PCB in Norway (in tonnes of PCB).

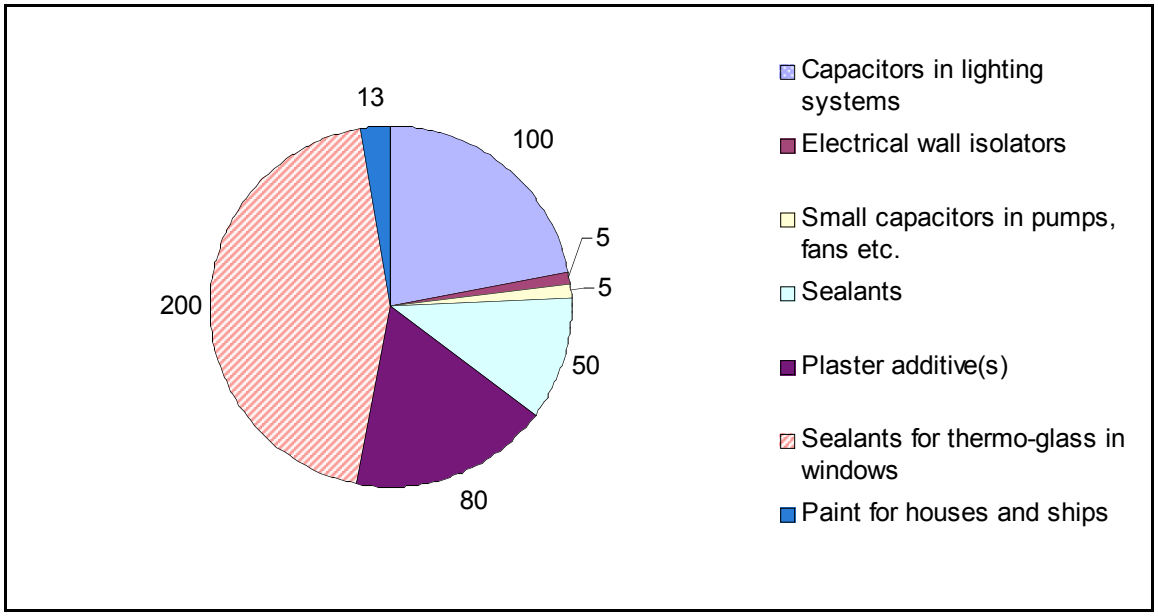

Figure 1 *Remaining PCB in tons in Norway distributed on different building components and materials (per year 2000).*

From the start, one of the main aims of the project has been to ensure that the results of the project are applicable for immediate implementation in the Norwegian building industry. The project therefore included preparation of examples of texts of practical use in connection with offering PCB removal works for tender. This is explained in a little more detail in the following.

3. NEW NORWEGIAN GUIDELINES FOR PCB REMOVAL TENDERS

The description texts are divided into a general part ”BOK 0” extensive general guidelines for the performance of the work, and a specific part ”BOK1” extensive detailed guidelines and requirements for the performance of the work.

Through the preparation of the BOK 0 and BOK 1 texts, emphasis was placed on elaborating the specification texts so that they could immediately be fitted into the normal basis of the specification [tender documents], which are widely circulated in Norway. In Norway almost all building and renovation works are specified with reference to the Norwegian Standard NS.

No proposal for the specification of PCB removal works was found earlier in the Norwegian specification system. Techno Consult and DEMEX have therefore, during the extension of the project, received an application from the Norwegian standardisation board with a view to formally adopting the specification texts in the general Norwegian documentation.

The BOK 0 example contains a grouping of the general requirements placed on the entrepreneur in connection with the performance of PCB removal works. The BOK 0 specifications thus contain:

- health and safety requirements
- references to existing Norwegian legislation
- requirements for the handling and removal of waste
- requirements for the quality assurance of the performance of the work

The example of the BOK 1 text was set up as a ”worst case” example, i.e. a situation taking as a starting point a building that has all known PCB-containing building components. Examples of task specifications are given for the removal of the following building components:

- thermo windows
- additives used in mortar and plaster
- paint
- joint putty
- capacitors in light fittings
- other low voltage equipment containing capacitors
- high voltage capacitors
- high voltage transformers

Through the preparation of the specification text emphasis has been placed on the wording as specific ”requirements” for the performance of the work, such that the specifications can be used directly in a situation involving work offered for tender.

4. FINDINGS IN ADDITIVES IN MORTAR AND PLASTER

In the 1990s PCB was found in facades in larger buildings in western Norway. The source was unknown, but a specific PCB-containing mortar and plaster additive or paint was suspected. Therefore the use of this PCB-containing additive or paint was investigated. This resulted in some new findings about:

- The specific use of a specific PCB-containing mortar and plaster additive
- The use of PCB-containing paint

4.1 Mortar and plaster additive

A Norwegian company in the period 1960-72 on the Norwegian market sold an additive named Borvibet that contained PCB. The most important characteristic was to improve the adhesion of the plaster to walls and floors. Experience is required in order to achieve good results in plastering, but this is something that most non-professionals (for instance “do-it-yourself” builders) do not have. Through the use of the additive, plaster adhered to the underlay as if it had been “glued”. Even an average do-it-yourself builder was able to achieve presentable plaster work. During the project we found no other additives containing PCB. The Borvibet that is sold today does not contain PCB.

The method chosen was to interview people who were active workers in the 1960s. We interviewed, salesmen, entrepreneurs and, in particular, professional bricklayers and craftsmen. In all 22 people were interviewed. Some of them did not know the product at all, but a number of them could give a considerable amount of information about its use. It was evident that the product had been far more widely used than had previously been thought. Most important was the information about whether the entrepreneur or even the individual bricklayer had decided whether or not to use Borvibet. Some entrepreneurs had tended to use Borvibet more often than others. The most desirable characteristic was the improvement in adhesion. Owing to the fact that less water was required the plaster became very hard, and was therefore particularly well-suited for heavily-used floors, for example on stairs or in corridors.

Specific constructions in which the product had been used were:

- concrete floors built in situ, under (and as an additive in) the levelling plaster
- floors in stairs and corridors
- under slate on stairs and floors

- plastering with bricks or tiles in bathrooms or around drinking fountains
- repairs to plastering

4.2 Paint

PCB has been used as an additive ("a softener") in chlorcautchuk paint. This kind of paint was thought to be almost exclusively used by the shipyards on steel ships and steel parts of ships. The chlorcautchuk paint was used from 1952 to 1975. The findings of PCB in facades on buildings led to the suspicion that such paint, and perhaps other types of PCB-containing paint, was also used on buildings. The method used to investigate this possibility was to interview people who were active in "the PCB-period", 1950 to 1980. We interviewed producers, importers, sales personnel, entrepreneurs and professional painters. In all 26 people were interviewed by telephone. Most interviews gave valuable information and led to one or two new persons to contact. We were unable to find any other kind of paint, except the chlorcautchuk paint, which contained PCB. This does not mean, however, that PCB was not used in other kinds of paints. Two specific products were traced and shown not to contain PCB, although one contained asbestos. The most important characteristic of the chlorcautchuk paint was its ability to withstand a wet and slightly acidic environment. In many instances the paint was found to have been used in such environments. PCB-containing chlorcautchuk paint found in an air-raid shelter and on the facade of a residential army building led to the conclusion that painted army concrete constructions should be investigated further in a new study. Other specific uses include farm buildings. An overview is given in the following table.

Table 1 Type of building and corresponding building construction where PCB-containing paint could have been used

Type of building	**Part of building/construction** **Indoors**	**Part of building/construction** **Outdoors**
Cowshed/pigsty	Walls and ceiling	Facades
Outbuildings on farms	-	Facades
Manure basement	Floor, walls, ceiling	-
Bunker on farms	Floor, walls, ceiling	Walls, roof
Building for electrical installations, such as transformers	-	Facades
Army building	Walls in air-raid shelters	Facades
Food industry	In production rooms: Walls and ceiling	-
Schools	Toilets: Walls and floor	-

4.3 Example of PCB in Norwegian hospital buildings

At the same as the PCB Guide was being developed the national hospital in Oslo (Rikshospitalet) was about to be demolished. "The Directorate of Public Construction and Property" (Statsbygg) engaged the authors to check the 16 buildings, comprising a total floor area of 50,000 m^2, for PCB in concrete and plaster. Considerable effort was made to choose the appropriate parts of buildings from which to take the material samples. The new findings about PCB in mortar and plaster, and knowledge about when the buildings were built and/or renovated were essential for the selection of samples. A total of 11 samples was taken from

walls (plaster) and floors (plaster and under slate). The samples were tested for PCB, and two of those taken from the floors proved positive. They contained 15.5 and 19.7 ppm PCB respectively, and were taken from the plastering on floors in two different buildings constructed in 1972 and 1962. They were both concrete buildings in situ. It was assumed that Borvibet had been used on the concrete floor before plastering, or as an additive in the plaster itself. The results of this search for PCB in mortar and plaster at the hospital verified the information from the literature study and the interviews.

The picture below shows part of the floor in the new administration building of the hospital. Samples were taken of the material under the vinyl tiles, which had been used to level off the floor. The result of the analysis revealed that a concentration of 19.7 ppm PCB was found in the material under the tiles.



Figure 1 *Picture of vinyl floor in the new administration building at the hospital (Rikshospitalet) in Oslo where samples were taken and analysed. The material under the vinyl tiles contained PCB in a concentration of 19.7 ppm.*

5. FOCUS ON FUTURE WORK IN RELATION TO PCB

The project showed that the source to PCB found on facades on various buildings in western Norway is not exactly known. Paint, mortar and plaster additives or sealants are the most obvious sources of PCB contamination of the facades. As an example, the source of the PCB contamination of the soil in a kindergarten was likely to be the outer wall of the building next door. The soil has been renewed, but the wall probably still leaks PCB. To remove such

pollution from our environment you first have to find the building with the PCB-containing facades. Depending on the source and construction, effective renovation has to be fulfilled.

5.1 Handling PCB on facades

We have suggested the following procedure for further work in relation to the decontaminate facades containing PCB:

- Buildings that potentially have PCB present in the facades are to be examined. A way to find PCB-containing facades is to make it mandatory to take a few samples of the facade material (mortar/plaster/paint) before starting to renovate the facade. Renovating facades usually starts with jet water washing which leads to waste water to the city's drainage system. The business permit of the facade entrepreneur can be linked to the proof of the harmlessness of the spill water from the jet water washing. This harmlessness can only be obtained by proving that common contamination in this kind of waste water, such as PCB, are not present.
- A number of buildings containing PCB in the facades should be investigated.

- The source of the PCB contamination of the facades should be detected by:
    - Mapping the history of the building
        - When plastered, with what kind of plaster
        - When painted, with what kind of paint
        - Is the paint renewed, and when?
        - Are the windows and/or sealants renewed?
    - Samples of the materials (mortar, plaster, paint, sealants).
- Composition of the results would probably lead to more knowledge about the problem, which will lead to a more precise selection of PCB-contaminated facades in the future.
- Depending on the construction, source and degree of contamination, decide on an effective method of decontamination and renovation.

The advantages would be that the knowledge about the former uses of PCB-containing paints, as shown in Table 1, would become more comprehensive. The renovation of such facades would be safer for the workers and lead to a reduction in the spreading of PCB to the environment. Specific safety measures will only be used where needed, which will lead to a greater cost effectiveness.

Quantifying Uncertainty In Whole Building Assessment Methods

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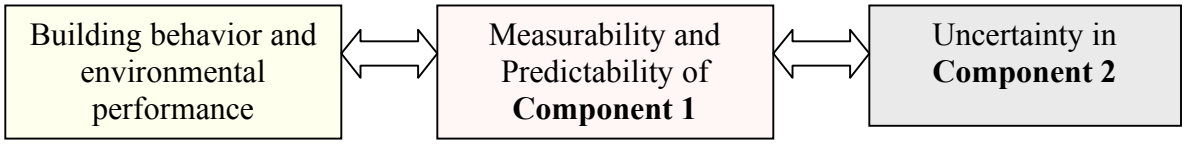
1. INTRODUCTION

Environmental research has grown into a trans-disciplinary activity in last few decades; one major focus has been to establish a robust basis to model inputs and outputs of ecosystems. Information exchange and data connectivity is no longer problematic, and the modeling of physical behaviors of many complex ecological or building related-phenomena has been available in practice for some time. However, the question remains: "Just how do we integrate across disciplines and synthesize knowledge so as to produce useful outcomes? How do we do this in an environment where data sources have different types and degrees of error, where some data types from disparate disciplines are even incompatible? How do we do this in an environment where the technology is changing by the month?" (Harris, 2002)

The building industry has seen a proliferation of 'green building' related tools and methods. Each of these tools has to deal with the inherent complexities of green buildings and ecosystem for a realistic output. In this context a very primitive question that should now be tackled is 'how accountable these tools are'. This paper explores a method to investigate accountability, and specifically occurrences of uncertainty, in the working of building assessment methods, and gives an account of the crucial components identified in the process.

2. THE CONCEPTUAL FRAMEWORK

A simplified conceptual framework is proposed for the assessment of tools.



2.1 Complex physical behavior and performance of green buildings

A range of factors, such as *abstract design criteria* (in terms of functional equations, and spatial planning), *specific service components' performance* and the coupled effects of *material science*, *climatic studies* and *human behavior*, make 'green' building performance an increasingly

complex phenomenon. Of special concern is the likely rift in the potential design and actually built design or potential performance and actual performance.

2. 2 Measurability and predictability of environmental performance

It is difficult to mimic building behavior as a subset of the ecosystem. The traceability of building's metabolism is not simple, however patterns of measurability can be identified in green buildings. Three patterns are identified-

2.2.1 Patterns of measurability in green buildings

- *Physical modeling: endogenous behavior of buildings.* Physical modeling corresponds to the response of a building to its most intrinsic needs such as climatic protection, occupancy demands, contextual surroundings and trends, and indoor environment quality needs such as ventilation, and thermal requirements. The behavior of functional components of buildings in response to these needs, such as building fabric, services skeletons, tends to produce a large number of parameters for handling.

  Successful measurement requires realistic follow-up of the huge number of variables and their multilateral behavior, and establishing accurate correlations between them.

- *Environmental modeling: the exogenous behavior of buildings.* Environmental modeling defines the building and its association with the ecosystem. A building's construction and operations involve a significant amount of inflows and outflows with the ecosystem. Methods such as Life Cycle Assessments aim to give an account of all such inputs and outputs.

  Successful measurement relies on a robust basis that takes account of all inputs and outputs plus the interdependencies of environmental criteria, and on the availability and reliability of the environmental information systems. A lack of enough environmental decision support systems has been reported, despite the urgency and the importance of the problem (Avouris, 95).

- *Indicators and benchmarks: the measurables.* These provide the support measurement units to indicate the above-mentioned behaviors. Each of the above-mentioned line of enquiries produces heaps of data and information, which needs to be synthesized and organized for any attempt of measurement, prediction and assessment and indicators offer that service.

  Successful measurement requires indicators to provide leverage points for action, ability to rightly measure the intended issue, critical linkages with all the other causes and effects, tendency to reconcile with the higher-level indicators and ability to respond to regional disparities. (Meadows, 1998)

2.2.2 Building Assessment Methods: the framework for measurement

Having identified an ad hoc pattern of measurability, building assessment methods can be pictured as a holistic and comprehensive model that, by systematically following the behavior patterns and activities, provides a framework for the organization and evaluation of the measurement units (i.e. indicators).

The performance of any such environmental assessment would depend on the caliber of the model to cover environmental impacts in the most holistic way and to impart well-deserved credits to the efforts in a consistent manner.

3. ARE ASSESSMENTS ACCURATE?

How do we expect assessment methods to perform in an atmosphere where all the patterns of measurability — physical modeling, environmental modeling and indicators/ benchmarks can be criticized for their share of errors? According to Treloar (Treloar, 96), standard industrial energy analysis methods have failed to completely assess input of ancillary activities such as services, which has resulted in incomplete assessments of complex products such as buildings to the order of 30-50%. This is a significant figure, which evidently can render composite ratings un-reliable and invalid, particularly for tools that assign high weighting to energy criteria.

Assessment methods, being in a position where they offer a whole building evaluation and reconciliation of all the data inputs to produce a unified rating, are prone to get corrupted with the inherent errors in measurement patterns. Furthermore, the framework of assessment process adds more parameters and mechanisms, and is supposed to undergo normalization and aggregation, and evaluation of information. A small error in any of the measurability patterns might have a tendency to grow manifold and eventually impact on the reliability of the rating.

A detailed categorization of possible error-types in measurability patterns is required at this stage; and indicators are expected to represent those error-types on behalf of other patterns. Very broadly 3 categories are identified -

- Systematic Errors- As a result of inbuilt problems, structure issues of Indicators
- Random Errors- Errors in data/ information recovery
- Blunders- Errors in misinterpretation and working errors

3.1 Quantifying Uncertainty

With possibility of error and variances in each of the input parameters, uncertainty in the assessment process needs to be quantified to increase the credibility of methods. Unlike the verification procedures such as 'Bestest' for simulation and energy rating software, assessment tools exhibit a mechanism that poses different challenges in verifications and real data validations. Bestest's Bestcase approach, which employs a simplified test case building for investigations, is also viewed as unsuitable, considering the significance of real world scenarios in tracing uncertainties in building assessments.

A method is proposed that utilizes a simplified tracking of the variability factors of different input parameters that actively contribute in the assessment process.

3.1.1 Selection of assessment method for investigation: Green Building (GB) Tool

Based on a review of existing assessment frameworks, including LEED (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment Environmental Assessment Methodology) GB Tool was identified as the appropriate vehicle for this study. The choice is based on the following considerations.

GB Tool is a comprehensive framework to assess buildings all over the world, is undergoing constant scrutiny, evaluations and updating. GB Tool can be customized to suit the assessment needs of different contexts, 'one that is designed from the outset to reflect the very different

priorities, technologies, building traditions and even cultural values that exist in various regions and countries'. (Larsson, 2000) GB Tool provides a comprehensive assessment framework and an ongoing evaluation.
As part of a live GB Tool case study in Australia, a thorough analysis is currently underway, locking in the occupancy-type and making it Australia specific. Participation in that study as a GBC national team member further facilitates an in depth understanding of the tool's workings and parameters.

3.1.2 Variable identification

A model is proposed that can facilitate a categorization of inconstant parameters of assessment process. The concept behind this model revolves around the fact that building assessment methods have a set of objectives to fulfill and the features of any such tool/method are designed and developed for the accomplishment of those objectives. Any failure in attaining one or more of the identified objectives can result in inconsistency of the assessment process and thereby uncertainty surfaces. The susceptible features can be tracked down to produce a list of 'culprit' variables.

Table 2 demonstrates specific objectives and corresponding features of method /tools. Three different sections represent the pre-assessment (development) phase, assessment phase and usage issues. 'Consistency' is the dynamic component of the process and is a result of all other processing. A fourth column is intended in this model that will record variables corresponding to each feature, which in turn correspond to the intended objectives.

Objectives: Assessment tools should do	**Factors responsible**	**Features of the tool/method that support the objectives**
Clear Intent of the tool Performance/ prescriptive	Adopt a suitable framework to account for the intent	Selection of indicators and units
Provide design support or project support	Transparency of the process and prescriptive nature of the process	Feature for quick view of outcomes of different options
Represent the context	Accounting for contextual settings, regional disparities and trends	Referring to context Regional weightings Appropriate benchmarks Region-relevant data
Provide Robust framework	Good coverage of environmental criteria	Comprehensive model Thorough input requirements Well-designed scoring system to rate building
Consistency of process: the dynamics of process	**Accountable processing of information**	**Accumulative effect of all features**
Data objectivity	Robust Input data requirement and documentation to fulfill measurement needs	Clear specifications for data entry to avoid any flexibility, misinterpretation and wrong entries
Ease of use	Easy articulation of steps	User friendly interface Not too complex
Universal approach	Coherence with other agenda	Connectivity with the output of other levels of tools for a integrated approach Results designed for wider applications

3.1.3 Rationale of error sources: Identifying the degree and causes of variances

Table 2: Categorization of features in the context of objectives of assessment methods

l errors
pported

information base of these patterns can be useful in providing the necessary foundation, which can then be used to extract the information required for the error-critique.
One of the examples of having variability in input parameters is the current scenario, of not having any scientific basis for the weightings to be given to the different environmental issues. It is yet to be known what impact this has on ratings. In a study done in Austria, the level of uncertainty was assessed in the Green House gas inventories. Results for all sources and gases combined indicated an overall uncertainty between 10.5% and 12% (Winiwarter, 2001). Any assessment method deploying greenhouse emissions as one of their input parameters inherit those levels of uncertainty.

3.1.4 Selection of an error-aggregation method

To account for the combined result of all individual errors, concepts of error propagation were investigated. Error propagation is a way of combining two or more random errors to predict a third. However the typical characteristic of environmental problems may demonstrate complex distribution patterns and may also require accounting for dependencies beyond just a linear approach.

For such problems, probabilistic methods are best suited, because they provide information regarding the full range of possible outcomes and the likelihood of each outcome (Freeze et al, 2002). Probabilistic risk analysis techniques, based on Monte Carlo simulation, offer to perform large calculations to produce different outputs, so as to model the uncertainty as a result of the variability and randomness in the input parameters.

3.1.5 @Risk (Palisade, NY): the variable compiler

To suit the nature of the problem, a sophisticated proprietary risk analysis tool, @Risk is proposed to be used. @ Risk's Monte Carlo base can randomly select the possible values of variables according to their probability distribution pattern and can simulate the results as a combined effect of those variances. In addition to Monte Carlo simulation powered mechanism, @Risk also offers features that allow defining interdependency, relative sensitivity and a range of distribution functions to best reflect the complex nature of the problem. But before the software can be deployed for investigation, a wide base of information, research and expert support needs to be laid down to endorse the error-assumptions and related analysis.

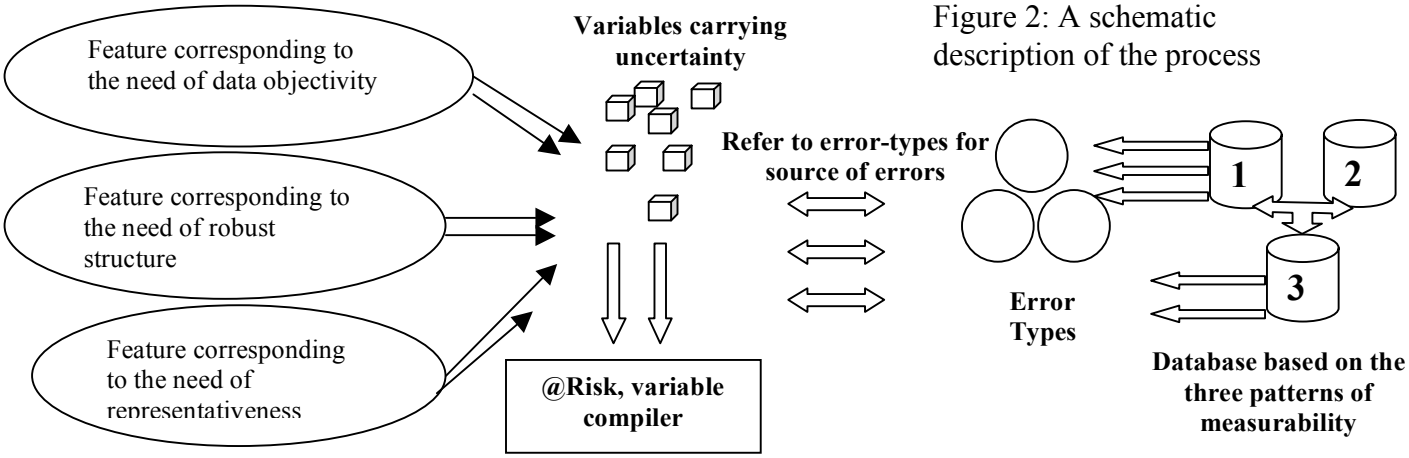


Figure 2: A schematic description of the process

As a part of an ongoing investigation, this paper only attempts to highlight the crucial steps of the process.

Defining Probability Distribution
As envisaged at this stage, the most crucial work of this investigation will be to determine the characteristics of the variables identified for uncertainty, and most probable distribution and range. The legitimacy of the whole process depends entirely on the realistic probability distribution of the variables, and the rationale of their possible values.

In the one comparable study so far identified, uncertainty associated with national greenhouse gas emission inventories is assessed. Due to the lack of information and to avoid a complex distribution model, a uniform distribution was assumed throughout. (Winiwarter et al, 2001). Establishing a manageable number of critical variables is recommended in order to have a controllable process of iterations and simulation, however the present research intends to achieve an increased level of process sophistication.

Case design
The other crucial process will be the way 'what-if' cases are designed. Scenarios should be designed that represents real-life conditions but are simple enough to deduce. It is intended to hold on to few crucial variables and maintain a threshold for holding some variables constant. As discussed previously the designing of such scenarios would be based on the information gathered on different patterns of measurability and a thorough analysis of the parameters of assessment method to be appraised. The multiple worksheet, spreadsheet-based framework of the GB Tool is an additional advantage, as @Risk requires the problem to be first defined in a MS Excel spreadsheet.

There are additional features that @Risk offers for a better modeling of the situation. They involve *variable sensitivity analysis* to help determine the relative impact of variables on the credibility of the process and a *correlation matrix* to account for the correlation between two or more interdependent variables. However, with the limited coefficients of correlations offered in @Risk, there is a need to assess its usability for environmental dependencies.

4. CONCLUSIONS

"Governments and society now require more accountability — and they require not just outputs (scientific papers), but also outcomes — science must make a difference". (G. Harris, 2002)
The most significant contribution of assessment methods to date is that they acknowledge the importance of assessing building performance across a range of issues beyond singular performance criteria such as energy (Cole, 2000). However, in order to produce outcomes and make a difference there is a need to test their credibility and refine them if required.

Performance predictions and assessment provide the basis for informed decisions, increasing chances for better buildings and minimizing risks for failures. (Papamichael, 2000). A refined and accountable building assessment method therefore should be capable of fulfilling a range of objectives of the building industry in its pursuit for greening:

- Induce change in the market trends with the induced demand for environmentally responsible products and strategies
- Alter practices and behavior of building professionals, stakeholders and occupants for the potential use of the buildings
- Make method popular with the users for an increased uptake

- Deliver a uniform and international protocol, international comparison for participating in the wider sustainability agenda

It is imperative that the error levels accumulated by any such assessment tools are understood and minimized, in order for them to deliver intended objectives. This research is developing a method that may assist in this process.

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Toolbox for Eco-Friendly Living

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1. INTRODUCTION

VVO is a public limited company producing housing services in Finland. It owns some 40,000 rental and right-of-occupancy homes around the country. Promotion of sustainable development is a central theme in all VVO operations. In the development of housing services, this means creating opportunities for environment-conscious living.

The residents' daily routines and consumption habits are essential elements for achieving success in environment-conscious building maintenance. Besides the development of technical solutions, VVO is aiming to actively create operating models that encourage residents to participate in taking care of their collective environment.



Figure 1 Good co-operation between residents, maintenance staff and the housing company is required to achieve the environmental goals.

2. ACTIVE RESIDENTS INFLUENCE THEIR ENVIRONMENT

Voluntary eco and energy experts make up the core of environmentally aware residential activities in VVO. These are residents with an active interest in energy and environmental issues who function as initiators and contact persons for these issues in their own residential building. The experts are given an information package and tools to support their role and action, and training sessions are arranged for them on various subjects. The experts are also sent newsletters on environmental and energy issues with special focus on current topics.

Each of the 12 VVO regional offices employs general managers specialising in environmental and energy issues to provide support for the experts. The general managers monitor and direct the implementation of goals in their responsibility areas and are in charge of arranging expertise training and local environmental activities in their area. From time to time, theme campaigns are organised on various environmental issues.

The VVO resident's guidebooks constitute the core of communications to residents. They present environmental and energy issues systematically along with many other instructions relating to the apartment and building maintenance and usage. A residents' newsletter issued quarterly regularly highlights themes relating to environmental issues and reports on successful campaigns and operating models. Residents who excel in environmental matters are given awards in an annual ceremony, along with co-operation partners.

The popularity of expert activities has increased continuously. At the end of 2001, more than 1,300 active residents were involved, half of them as energy and half as eco experts.



Figure 2 The energy expert's toolkit contains the necessary tools for measuring water and air flow in apartments.

3. ENERGY CONSUMPTION IS THE MOST IMPORTANT ENVIRONMENTAL FACTOR

Residential activities with a view to saving energy have a long tradition at VVO. The first energy experts started work in 1993, but energy consumption has been systematically monitored for more than 20 years, and now the consumption has settled at a stable, efficient level. Since 2000, the consumption reports have been filed on the Internet, which has opened up new opportunities for maintenance companies and residents' representatives to participate in monitoring consumption in their own building.

All energy experts and elected tenant representatives receive a control report on their building's consumption four times a year. The experts also have the opportunity to join in on control rounds with heating specialists, maintenance technicians and general managers and participate in the planning of proposals for action. Water savings have been particularly successful in the past few years: the level of consumption has decreased by 15% since 1995.

VVO offers all its residents the opportunity to influence the environmental impacts of their energy consumption by making a joint decision to purchase the eco-labelled "Norppa" (seal) electricity, which is produced from renewable resources and meets the criteria of Nordic associations for nature conservation.

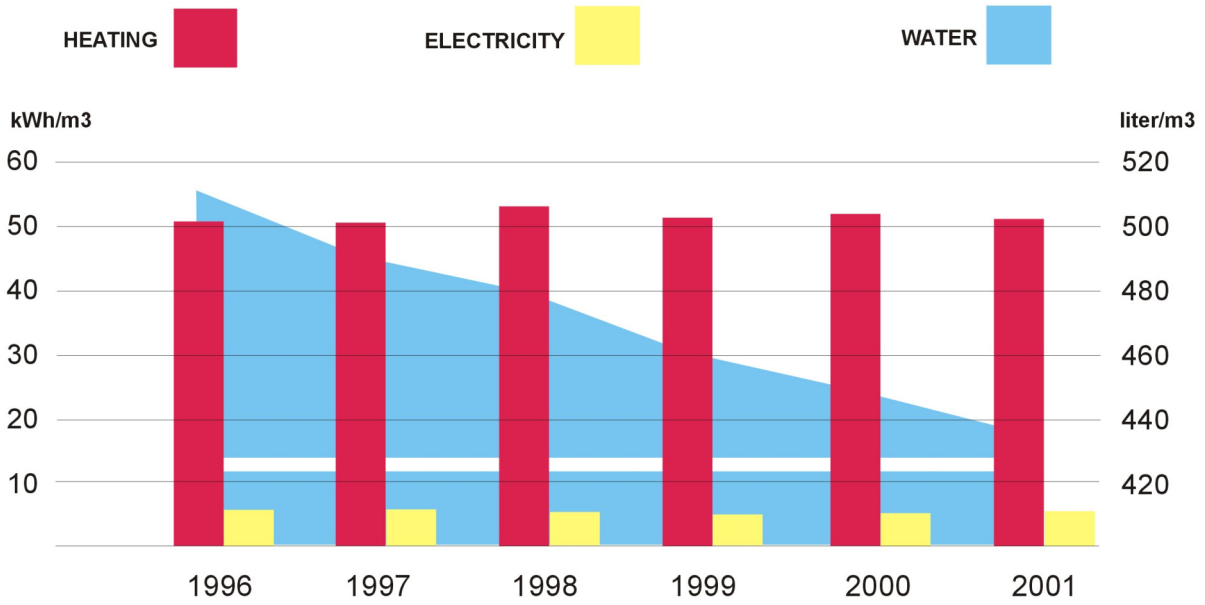

Figure 3 Energy and water consumption in VVO housing

4. 'WASTE DIET' REDUCES WASTE VOLUME

The waste management of residential housing companies in Finland is guided by municipal regulations. Since there are VVO sites in more than 70 municipalities, it has not been possible to formulate strictly uniform measures for waste management. Clear targets have nevertheless been set: the volume of mixed landfill waste is reduced by paying attention to consumption habits and by promoting sorting at source. The campaign for increasing the efficiency of waste management at VVO housing was dubbed the 'Waste Diet'.

To support the Waste Diet, VVO ensures that the basic requirements for good waste management are in place: appropriate and safe waste disposal facilities and sorting bins in the individual apartments. The waste disposal points provide clear general sorting guidelines, and instructions for special waste disposal (Christmas trees, New Year's horseshoe tins, removal waste, repairs, etc.) are given separately.

Guidance and help is always offered to residents when they express an interest in further sorting of waste. Many creative ideas have been brought forward around the country and have led to more efficient waste sorting. As a result of the Waste Diet, the volume of mixed waste went down by 18% in three years. This was felt in the reduction of waste expenses, which had previously been rising sharply.



Figure 4 Tricky sorting test at eco experts' theme meeting.

5. INCENTIVES FOR ACTIVE INITIATIVES

The activity and initiative of residents aiming for better management and development of the shared environment is systematically supported and encouraged by VVO. The requisite tools, materials and planning help is provided for residents willing to do voluntary tidying up and repairs. Residents carrying out management and repair work stipulated in the house budget can earn new high-quality materials, fixtures and fittings for their home through the active benefit system. When work is carried out by a team of residents, they can receive compensation in the form of improvements to jointly used facilities.

All building budgets have an annual allocation for residential administration, which is spent on organising house committee meetings and house festivities. This is to ensure that the threshold to becoming acquainted with the neighbours and to discussing house rules and targets is as low as possible.



Figure 5 Children like to join in tidying up the communal areas, and they learn to take responsibility for their environment.

6. INDIVIDUAL APARTMENT REPAIRS

In VVO's building maintenance, apartment repairs are kept separate from the phased maintenance system applying to building components and technical systems. The arrangement ensures, on one hand, optimal usage of resources, while at the same time offering residents extensive opportunities to influence the repairs in their own apartment.

The life-cycle efficiency of repairs is also influenced by rewarding residents for initiative and good care. For instance, after the first ten-year control, those residents who have kept their apartment in good shape can choose quality improvements for their home from the "VVO repairs collection", including new surface materials, fixtures and fittings, without a raise in their monthly rent. When new residents move in and are willing to carry out repairs, they may choose the wallpapers and paints if they do the work themselves.

VVO's own paint brand received the EU eco label in 1999. Environmentally friendly options have been favoured in all the toolkit and repair materials.



Figure 6 Toolkit for the Move-in renovation.

7. URBAN NATURE STARTS AT THE FRONT DOOR

In an urban context, natural elements in the immediate vicinity of housing play a central role in residential well-being and satisfaction. Many VVO environmental experts have discovered that gardening is fun even in an urban context. The pretty shrubs and flowers they plant and care for bring joy to all residents. They also help to convert the areas around the buildings from a passive no-man's-land into active and unique living environments.

To develop the gardening activities, VVO co-operates with local gardeners, who provide guidance for the general managers and environmental experts on issues concerning the care of the green spaces. They participate in the regular "garden walks" where the general manager, residents' representatives and building maintenance company staff get to know the green area around the buildings and agree on necessary maintenance and development measures.





Figure 7 On the left: residents' flower beds cheer up passers-by. On the right: eco experts on a study trip at the local gardening school.

8. CONCLUSION

All in all, VVO's experience shows that developing an environmentally responsible residential culture contributes not only to improvements in ecological sustainability and economic savings, but also to more functional residential communities and pleasant and safe living environments.

LCA in the cement and concrete industry. The process of implementing sustainability issues in a chain of industries

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1. INTRODUCTION

This paper discusses the European Life Cycle Inventory of Concrete.

What is discussed? You probably expect to read about the LCA results, the data that have been collected, the results that will be brought to the market or the arguments why to use concrete for sustainable building. I could have told you about that, but I decided not to discuss the project's results but the project's process.

Why? Because the project results are there, as they are. By reading this, you know about them. You are all experts here at the conference, so I do not have to explain what they are and how to use the results. But do you know how the results were obtained? No. In my opinion the process is as interesting as the results. In future other projects like this will be carried out, by you, by me and by others. Current IPP and EPD developments will urge industries even more than now to carry out LCAs. We can learn from each other how such projects can succeed. And of course, this is not really new to you, neither is it to me. But the study of De Bruijn (Bruijn, 1998) for the Dutch LCA-2 project already showed the importance of the procedural organisation of LCA studies. You can see this as a case of their guidelines.

The aim of my presentation is to share knowledge and practical guidelines for future projects.

2. BACKGROUND OF THE PROJECT

Of course I owe you some information about the project:

2.1 Participants

Ideally, partners in product chain co-operate in an LCA study. The most significant advantages are obviously the possibility to obtain a consistent data quality throughout the product chain, and the possibilities for co-operation in achieving improvements in the product's chain.

What about concrete? You probably know about national initiatives in which the cement industry and concrete industries participate. Two years ago there was hardly anything like a European co-operation between all the branches related to concrete. CEMBUREAU, the

European cement industry association, took the initiative for a co-operation in an LCA project.
Six European associations, representing the concrete industry and constituents thereof, decided to join forces to develop LCAs of concrete and concrete products on a pan-European basis. Together they are the Joint Project Group(JPG):

- BIBM, International Bureau for Precast Concrete
- CEMBUREAU, the European Cement Association
- EFCA, the European Federation of Concrete Admixtures Associations
- EISA, the European Independent Steelworks Association
- ERMCO, the European Ready Mixed Concrete Organisation
- UEPG, the European Aggregates Association

The project was assisted by an independent consultant, INTRON, experienced in LCAs for the building industry and also for concrete. The project was peer reviewed by IKP from Stuttgart University, also an experienced institute in LCAs of building products.

2.2 Results

The main outcome of this study is:

- An LCI database with data for LCAs of concrete;
- A new and tailor-made LCA tool, EcoConcrete, to calculate LCAs of concrete according to 3 assessment methodologies;
- EXAMPLE LCAs of concrete for ten functional units.

The project was carried out according to ISO 14040-14043.

Neither of these results are for sale. Why not? It has to do with the communication strategy of the JPG, which I will discuss in the next chapter.
If you want to know more about the results, you are most welcome to contact me at the conference, or you can contact CEMBUREAU. The address is at the top of this paper.

2.3 Organisation

The Joint Project Group started the project and commissioned INTRON to do the LCA work. The branche representatives were the contact persons and the ones who attended meetings with INTRON.
Periodically, the JPG met together with INTRON, to discuss progress and steps to be taken. CEMBUREAU chaired the meetings and fulfilled the secretary role.

3. THE PROJECT'S PROCESS

In spite of the advantages for LCA and in spite of the identification of the sense of urgency for the study, meeting the challenge of co-operation within a chain is no sinecure. Nevertheless, the JPG was founded and the LCA study seemed to be an excellent case to start life cycle thinking.

The foundation of a group like the JPG is just the first barrier. Others have to be faced in the further process. A representative of one of the project's participants presented it as follows on the seminar 'Concrete for the Environment' on 9 April 2002 in Stockholm:
"Projects like the LCA of Concrete tend to have neither a well-defined start nor a well-defined end. I can tell why we started the project, but I cannot tell you where and when."

The JPG was aware of the potential threats for a successful project. Therefore, the consultant should not only have a thorough LCA knowledge, but as important were the management

skills. During the whole project, the consultant's project manager stayed in touch with the JPG secretary about the progress. It was this emphasis on the management, which I believe, was one of the key factors for success. On the whole, the project results were obtained within 18 months, which is in my opinion a short period for such a complex project.

In Table 1 you find an overview of the process items that are relevant for an LCA study, as mentioned in (Bruijn, 1998 and the way they were dealt with in the JPG project.

Table 1. Key factors for a successful LCA project in a chain (process items from (Bruijn, 1998) and (CML, 2001))

Basic conditions	**The JPG "LCA of Concrete" project**
Sense of urgency	Fulfilled: international developments on Environmental Products Information, Perception Survey on Concrete by European Schools of Architecture, competitor's similar actions and unwarranted denigrations.
Stakeholders willingness to commit themselves to a process design	Fulfilled: the JPG was founded.
Process participants possess a minimum level of substantial LCA expertise	Partly fulfilled. It was known from the start that there was a knowledge gap between partners. Dealt with by starting meetings with knowledge dissemination of LCA, stepwise. Bilateral contacts for further explanations (could be improved).
Process item	**Dealt with in the JPG project**
Implementation of LCA tasks	
1. Overall process management	Tight project management, detailed planning.
2. Role and duties of the process manager	Fulfilled by the project leader of the consultant, together with the secretary. Went well due to the authority of secretary and chairman and the fact that the project leader did not carry out LCA tasks.
3. Role and duties of the LCA practitioner	Although having a clear role, it were the LCA studies that were subject of discussion at the end of the project. The text formulation and conclusions sometimes conflicted with the stakeholders expectations and interests. Extra time reservation for the LCA practitioner at the end of the project is a point of improvement.
4. Role and duties of the reviewer	The role of the reviewer was clearly defined before the review started. This has been no point of discussion in the project.
Representation of interest	
5. Selection of process participants	The JPG was a balanced group with the most relevant stakeholders involved. Missing actors in the chain were contractors and demolishers. The JPG members had

	difficulties to obtain information from these people, since life cycle thinking is quite unusual for most of them.
6. Structures and interests to be respected	Chairman overviewing the project's contents as well as the political arena.
7. Participation	During the project it became more clear to the stakeholders what effort was required from them and what type of results would be obtained. Although responsibilities were agreed upon before the start of the project, it could have been improved by detailing the procedure of decision-making and influence of people.
8. Commitment	The project was known to be a learning process. Nevertheless, there was a 'binding condition' at the start that turned out to be problematic: that the JPG members would collect the LCI data. Problems arose with data from contractors and obtaining representative data took more effort than expected.
Process progress	
9.Balance between content and process	The text in the final reports were subject of a consensus process. This was unforeseen.
10. Balance between speed and thoroughness	Speed was required, but there was time delay in data collection due to unforeseen effort in data collection. The consultant had to reshuffle the own time planning to end up in time.
11. Outside influences	Not important in the project.
12. Honouring input	Due to the strong involvement of secretary and chairman (also 'behind the screens'), all interests were honoured sufficiently.
Process outcome	
13. Clarity of purpose	Although clearly set out at the start and despite of the concrete results, there was discussion about what exactly was the project's end.
14. Relation between LCA findings and process conclusions	The LCA findings should be the basis for sustainability argument. The formulated findings sometimes conflicted with stakeholders interests, thus hampering the formulation of arguments.
15. Relation between process conclusions and implementation	The discussions were useful for determining the external communication strategy.

Communication is one of the key success factors. We distinguished:

- Communication within the project group, by knowledge dissemination in every meeting and bilateral contacts in between the meetings.

- Communication outside the project group but within the project: there was a newsletter for those not directly involved in the JPG, but who had to collect data. This could be improved in future projects. The newsletter was not always distributed. More personal contacts and probably training would have been more efficient.
- Dissemination of the results will be controlled. To maintain a level of professionalism, it is decided to license people who have passed a kind of exam.

As you probably know, it is difficult to discuss potential threats and the way to overcome them, before the project's start. Especially when the potential threats have to do with the level of knowledge of those involved. At the start of the project, a story was told about the process to come . A citate out of it: "He (Mr Producer) phoned the consultant and told him: "This is all very nice but I'm not so sure anymore that this is what I wanted. I can't put this report in my product-specification-leaflet. And by the way, tell me what these figures mean: Am I doing well or not, compared to my competitors?""
Everyone laughed when hearing it, but at the end of the project we concluded that this was indeed the process we followed.

4. CONCLUSION

The process management of an LCA project, especially with many partners involved, is as essential as the LCA knowledge. It requires a tight project management with special attention or:

- Knowledge dissemination at all levels
- Communication
- Responsibility agreements
- Decision-making procedure
- Stick to agreements
- Authority of project leader

LCA knowledge of the commissioner as well as management capabilities of the consultant should be open for discussion at the project's definition. It is not a shame to reserve part off the project's budget for process management. On the contrary, if you aim for a succesful project regarding to quality, time planning, perception of success and acceptance of results, you'd better spend some extra time on the process, which will be returned during the project.
The management approach in the JPG project resulted in a successful project, with the foreseen results obtained within the planning.

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Comparison of four life cycle based environmental assessment tools of buildings, real estates and infrastructures

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INTRODUCTION

The concept of sustainable development carries with it the concept of the long-term mutual coexistence of the physical economy and the natural environment. In making sustainable development operational, human activities at different levels should be checked for compliance with some kind of quantified goals. Checking compliance requires compilation of environmental information. Different decision tools, everything from physical tools and computer softwares to methods and processes, can be used for gathering and analysing information from assessment of any system making up the physical economy.

One of the areas that deserve a holistic assessment is the built environment comprising of buildings, real estates and infrastructures.

Different environmental assessment tools have been in use and under development not only in compiling and processing information but also in interpreting the processed information associated with assessment of the built environment. Such tools incorporate methods for structuring, analysing and partial or full evaluation of environmental, economic and social impacts from different components of the built environment.

EcoEffect, ELP, GBTool, and ORWARE are four of such tools that are either under development or in use in Sweden. These four are selected out of the number of similar tools considering the common geography and context of their development and/or use and the author's exposure. This paper discusses these tools in light of such aspects as issues addressed and areas of application.

OBJECTIVE

The objective of dealing with such task of comparing tools is to facilitate sharing of experiences between the developers of the tools; enhance the knowledge of potential users about the differences and similarities between the tools; and consider possibilities of integrating efforts to come up with a tool that can address the demands of the interest groups of each tool. This will hopefully help guide the ongoing development work and/or the further use of the tools in practice.

METHODOLOGY

In establishing methods of comparison and evaluating higher level approaches and tools such as EIA and LCA, Baumann and Cowell (1999) have developed evaluative framework for conceptual and analytical approaches. This framework was used for comparing ELP, Eco Quantum, BEE 1.0, BEAT 2000 and EcoEffect by Forsberg and Burström (2001). With the belief that the framework is more applicable for higher level approaches and conceptual tools(not at the level of such application or end-use tools as those subject for comparison in this paper), the framework is not adopted as a basis for comparison. This is because the tools

are developed by combining parts of different higher level approaches and tools that cover different span of concepts and principles.
For the above reason and considering the fact that the tools are still evolving, a simplified comparison between these four tools is done by answering such questions as where and how life cycle thinking is used; what type of issues they address; and what areas of application are possible. These aspects are selected with the aim of doing an overview comparison without going into detail. This approach is partly similar to Bequest framework of mapping sustainability assessment tools(Sunikka et al., 2000).

OVERVIEW

A brief overview of the tools is given below as to what the tools do.

EcoEffect

In EcoEffect (fully described in Glaumann, 1998) the object of study is a piece of real estate defined by law, often referred to as a property, composed of a building (residential or office premises) and its surrounding developed area. A comparative assessment is done where a property is assessed for its merits and demerits against a reference property. EcoEffect consists of five modules that can be used independently. These are modules for material use, energy use, indoor environment, outdoor environment and life cycle cost. The EcoEffect computer program is developed using Microsoft Access™ as a platform.

ORWARE

In ORWARE (fully described in e.g. Eriksson et al., 2000), the object of study is a waste management system. As an evolving systems analysis based tool, it is used to assess the performance of different waste management options. The tool consists of different sub models for transport, treatment, and disposal of different types of liquid and solid waste and recycling of materials. Flows between sub models are described by a vector of several substances of different relevance to the system. The separate submodels can be combined with a high degree of flexibility for the design of a wide variety of waste management options. It is these processes or their chains that make up the scenarios that are the core features of all ORWARE studies. The ORWARE model is built using MATLAB™ with its graphical interface SIMULINK™. The results of simulation are transferred to Microsoft Excel™ for a user-friendly result presentation.

GBTool

The object of study for GBTool (fully described in e.g. Cole and Larsson, 2002) is a building currently of three types namely schools, multifamily residences, and small-scale office buildings. GBTool is an operational software of Green Building Challenge, an international collaborative effort to evaluate and improve the performance of buildings. Green Building Challenge was initiated in Canada in 1996 by Natural Resources Canada, and currently comprises a group of about 20 contributing countries. GBTool helps to assess and evaluate the energy efficiency and environmental performance of buildings in comparison with pre-defined bench mark values that are core feature of the tool. The GBTool is built as a workbook in Microsoft Excel™.

ELP

From the perspective of the type of results that can be obtained from ELP (Environmental Load Profiles), five levels of object of study can be identified. These are individual, household, building, real estate and area level. ELP helps quantify environmental load in order to assess the achievement of objectives during both the planning and the design phases of development works and for areas already developed. At an individual level, the environmental load is presented per head while at the household, building, real estate and area levels it is calculated per square meter. Further description of the tool can be found in Fyrhake et al.(1998). ELP was initially developed for use in Hammarby Sjöstad, a housing project that transforms an old docking and industrial district into a modern part of the city of Stockholm with 8000 apartments for 30 000 people. The tool is still under development using Microsoft Access™ as a platform.

COMPARISON

As mentioned in the overview section, the type of object under assessment in each tool is one possible way of putting the tools in context. Furthermore, life cycle thinking, issues addressed and areas of application of each of the tools are discussed in comparing them.

Life cycle Thinking

The fact that the extent of life cycle thinking involved in the tools is taken as a yardstick for comparisons of the tools is by no means to undermine other issues that are incorporated into the tools. It is simply to check to what extent the assessment tools have a holistic approach in terms of addressing the whole picture rather than focusing on a piece of reality.

In ORWARE, the whole line of processes is assessed using life cycle methodology. Seen from the point of entry to the waste management system, energy consumed and fuels used are followed upstream and the waste is followed downstream as it passes through different treatment processes. ORWARE unlike the others is spatially unconfined i.e. the geographical delimitation is wider. An additional feature of substance flow analysis in ORWARE makes it well suited for accounting of physical flows such as pollutant and heavy metal flows.

A life cycle approach is used in EcoEffect on the material and energy modules of the tool. A database of life cycle data lies behind these modules. The manufacture and transport of the building material; onsite construction work and other processes are parts of the material use module. In the energy use module, the electricity and district heating consumption by the property are assessed.

Any possible inclusion of life cycle thinking in GBTool depends more on the external sources of the data used than calculations internal to the tool itself. These external sources are often other tools or models. GBTool is more of a framework accommodating a variety of building assessment tools including LCA (Trusty et al., 1998) where the predicted or potential performance of a building before occupancy(not during operational conditions) are dealt with(The Building Group, 2002).

ELP covers the construction, operation and demolition phases at all of the three spatial levels namely building, real estate and area levels. Furthermore, maintenance work is considered at the building level. Despite the variety in the extent of inclusion, all four tools have a life cycle thinking at least as a background but the core issue is to what extent this life cycle lies within the tool. In GBTool, most of the data is fed as a ready-made from external models or tools whereas in EcoEffect, ORWARE and ELP relatively much more data is calculated within the tools.

Issues addressed

In general all four tools deal with more or less the same dimension of sustainability namely the environmental dimension. The economic and social dimensions are less developed.
EcoEffect's material use, energy use and parts of the indoor and outdoor environment modules address the environmental dimension of sustainability. The material use module in principle takes care of natural resource consumption, release of emissions and waste and energy consumption. Energy use associated with the construction and demolition of a building is not considered yet. The amount of energy for this phase is much less than that for the use phase. The latter is calculated in EcoEffect. The use of water and handling of solid waste and wastewater during operation and use are issues that are currently under development using LCA.
In ORWARE, in addition to material and energy flows, economic flows are also included. The impact of the waste management system on the natural environment is considered in terms of both natural resource depletion and impacts due to emissions that end up in the environment. The model calculates emissions to water and air, and the amount of residues returned to arable land.
In GBTool, resource consumption, environmental load, quality of indoor environment, cost, and functionality are addressed. Predicted consumption of energy, water, land use, materials, as well as emissions, waste and wastewater, some parts of indoor environment are in quantified form whereas most part of indoor environment and other issues are based on qualitative data.
In ELP, as in the case with the other three the most extensively addressed dimension is the environmental impacts recalculated from the magnitude of material and energy flows, water use, hazardous waste, and nuclear waste discharges. Common to both EcoEffect and ELP as well as GBTool are the indoor comfort and health aspects. Depending on how one looks at the social dimension of sustainability, these indoor comfort and health aspects belong to this dimension. ORWARE has to a limited extent some consideration of developing a social dimension. The economic part of ELP considers the remediation costs incurred by society. In principle, EcoEffect calculates a life cycle cost of the real estate with possible scenarios of price change. ORWARE addresses the economic dimension with a better format differentiating between financial costs related to the capital and operating costs of the processes and welfare costs related to economic evaluation of the environmental burden shouldered by society. The economic part in GBTool so far has been an optional part.
Since ORWARE is not dealing with a building per se but rather the processes of waste management that are housed in the building, energy and material consumption and relevant emissions associated with operating the processes are in focus. The impact of the building phase of the waste management system as an infrastructure producing and consuming energy was studied. The study showed that there are two cases where the building phase energy and emissions for plants with high capital cost become relatively significant.

1. where the process involved in operating the plant is less energy intensive or/and
2. when the technology used is emission free.

Areas of application

Different applications of the results obtainable from the tools is possible including research, bench marking, decision making, knowledge enhancement, etc thereby addressing different groups.
EcoEffect aims to be of use for architects, designers, owners and managers of real estates for assessing and comparing existing and planned real estates. ORWARE is useful for research institutions, municipal and private owners of waste management, energy production and other

similar utility infrastructures for comparison of existing and new ones, for research and technology assessment. The ORWARE modules can be used as an aid in the design of a waste management system for a city, municipality or other politically or geographically defined area. ELP addresses the same range of users as EcoEffect except for an additional target group namely urban planners since ELP can be used also for area or district level assessment. ELP will also be used as an instrument for monitoring environmental objectives and as a tool for evaluating grant applications submitted to the LIP (Local Investment Programme)(LIP Stockholm, 2002). Since GBTool provides flexibility for assessment criteria and data requirement to respond to regional and national climatic and cultural conditions, the target groups can vary accordingly.

While still being under varying level of development, all four tools have been used in different cases.

The EcoEffect tool for instance has been used for assessment of three buildings in the 2001 European housing exhibition, BO01 in Malmö, Sweden.

ORWARE has been used in assessing different scenarios of waste management systems of Stockholm, Uppsala, Älvdalen, Värmdö, Växjö, Falun, Borlänge and Jönköping. It has also been used in other application areas such as comparing an organic fertiliser plant against synthetic fertiliser plant by *Norsk Hydro* and by comparing large-scale waste incineration against large scale composting by *Birka Energi*.

The GBTool has been used by participating countries for the assessment of buildings as part of GBC '98 and GBC 2000 processes. As of this writing, the latest version of the tool is under use for further assessment works, the results of which will be presented in the Sustainable Building Conference in Oslo in September 2002.

ELP was used as a means of helping the players involved in achieving the environmental objectives for three districts of Stockholm namely Hammarby Sjöstad, Östberga and Skärholmen involved in an ecocycle project.

DISCUSSION AND CONCLUSION

From the very same intention of assessment of built environment to the types of issues addressed and aspects considered, there are similarities as well as some differences between the tools. The similarities can be reinforced and utilised for initiating common efforts towards which enough resources of knowledge base and finance can be pooled. It is beneficial to critically examine if there is a potential for developing a comprehensive and simultaneously non complex tool that could be applied for decision oriented assessment of different kinds of buildings, real estates and infrastructures.

If this is impractical, development of tools should be guided towards helping planners and managers in aiding their decision in light of rendering the construction and operation of these objects of built environment sustainable.

It is possible to see from this simplified comparison done that two of the tools namely ELP and EcoEffect are relatively closely related to each other. The other two are less similar with the first two and with one another. Any possibility of merging between the tools is thus relatively reasonable for ELP and EcoEffect. On the other hand, connecting EcoEffect and ORWARE and thereby make them work consecutively would give the chance of assessing a wider system that links a residential building with a local waste treatment plant, drinking water production and energy production plant. The core principle of defining a bench mark prior to using GBTool makes it different from the others and hence hinders the possibility of integrating it or connecting it with the other three.

One of the difficulties in making comparison between such tools based entirely on few written materials about them is the difference in terminology. There is a risk of misinterpreting the way such different terms as energy use, life cycle, etc are used.
Systematic frameworks corresponding to that of Baumann and Cowell(1999) should be developed and used for a full and structured comparison of the tools once they are fully developed and well documented.

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Integration of daylighting, lighting control and HVAC system design in Concordia Engineering building

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1. ABSTRACT

This paper discusses major façade design options for the new Faculty of Engineering building at Concordia University in Montreal. The stated approach of the design team was to develop a green building and integrate concepts such as daylighting and natural ventilation. Detailed energy simulations have been performed in order to present recommendations on the choice of façade, glazings, shading devices, lighting control options, and natural ventilation. Integrated thermal studies, a daylighting analysis and impact of the above on HVAC system sizing are also presented.

2. ENERGY ANALYSIS OF FAÇADE DESIGN OPTIONS

2.1 Façade Options

The major objectives of this simulation design study are maximization of daylight utilization, optimal control of solar gains, reduction in electricity consumption for heating, cooling and lighting and also reduction of peak loads, while maintaining good thermal and visual comfort. A typical floor (11th) was selected for energy analysis, to simultaneously select and optimize the fraction of façade area that will be glass and the properties of the curtain wall and the windows. The base type of glazing chosen was clear double-glazed low-e. The thermal resistance of the spandrel (opaque) section of the curtain wall was a minimum of 3 RSI, to meet energy code recommendations for Montreal. Integrated thermal studies were performed for different glazing R-values (0.52, 0.67 and 0.85) and different fractions of glazing area of the façade (1/2, 2/3 and 3/4). As shown in section 2.4, the optimum glass fraction of the façade is two thirds and the optimum window R-value 0.67. Also, by choosing a glazing R-value of at least 0.67, thermal comfort calculations showed that perimeter heating may be eliminated. This results in significant capital cost savings and increases the useable area of the perimeter offices.

2.2 Control of solar gains, shading and daylighting analysis

The building is 16-storeys high and two of its main facades are facing approximately SW and SE respectively. Thus, shading devices must be utilized to control solar gains and prevent from overheating, while at the same time creating a high quality visual environment in the perimeter offices. The shading options considered are: (i) motorized reflective venetian blinds integrated in double-glazed low-e window and controlled by the building automation system (ii) roller blinds with variable transmittance (iii) a translucent glazing unit with honeycomb insulation between

glazings (60% transmittance) and (iv) combinations of roller blind in the middle section of the window and motorized venetian blinds or translucent honeycomb glazing in the upper third. Figure 1 illustrates the last option where roller blind is used in the middle third and motorized venetian blind in the top third, together with other concepts investigated for a typical perimeter office, such as photovoltaic panels integrated on the spandrel.

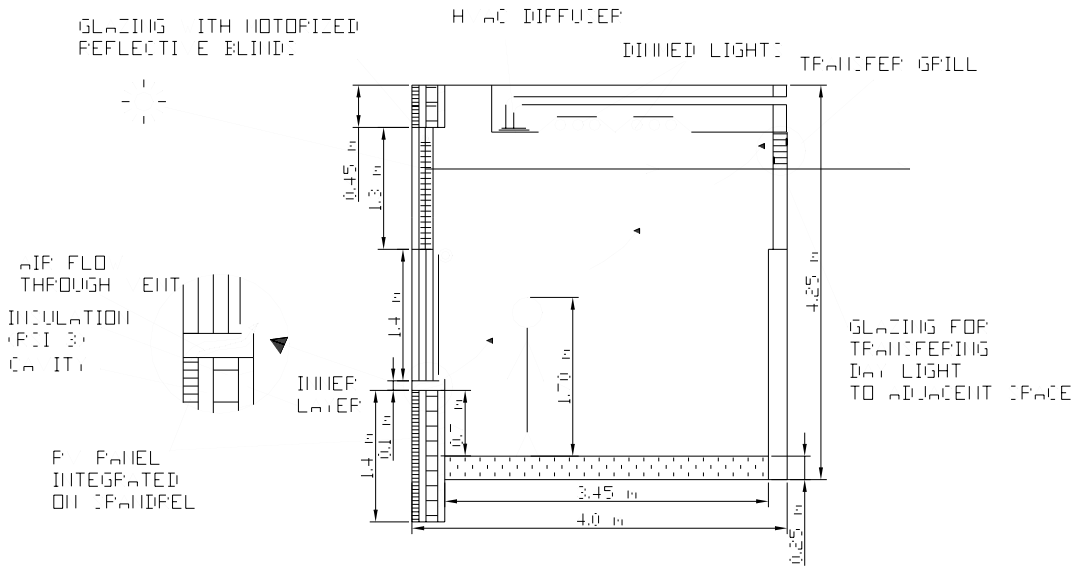

Figure 2. The multifunctional façade with the daylighting and shading design options for typical perimeter office.

The choice of the optimal shading device was based on visual comfort, daylight quality, energy efficiency, thermal comfort, appearance, cost and control aspects. Roller blinds may ensure privacy and can be open during overcast days to allow maximum daylight in the room. On clear days, they may diffuse daylight and their transmittance can be low in the bottom half and higher in its upper part. Motorized venetian blinds block direct sunlight, reduce cooling loads and allow view to the outside. Moreover, they reflect daylight towards the ceiling and improve the daylight uniformity in the room. The honeycomb translucent glazing has good thermal resistance, but it creates glare on clear days and can lead to overheating. A detailed daylighting analysis was carried out to investigate the daylighting performance of each system. Illuminance distributions on the work plane of a typical 4x4x4.25 m high perimeter office on the SW façade were determined for every hour in the year, using each of the shading devices and combinations. Athienitis and Tzempelikos (2002) developed a methodology for optimal operation of the motorized venetian blinds and calculated their transmittance as a function of blind tilt angle, solar incidence angle and sky conditions. Fig.2 shows typical results for the most important cases. A December afternoon was chosen for this graph because this is the worst case in the year; the sun is low and the venetian blinds have to close at a high angle to prevent glare, blocking most of the daylight. The translucent glazing is not included in Fig. 2, because even in this case the illuminance reaches very high values (6000lx). For almost all the other cases, the venetian blinds perform better than the other systems. Comparing all the results, the best solution is the combination of motorized venetian blinds (top half of the window) operated by the building automation system, and a manually controlled roller blind (bottom half of window) as shown in

Figure 1. The venetian blinds block sunlight and improve daylight distribution in the room, while the manually controlled roller blind gives the occupants the choice of changing their visual environment and it provides privacy. Under normal circumstances, the roller blind should be open during overcast days and closed during sunny days. Also, by using this kind of system, the control points are dramatically reduced (1-2 points on each façade), because the venetian blinds operate uniformly on each façade (if there is no shading from adjacent buildings).

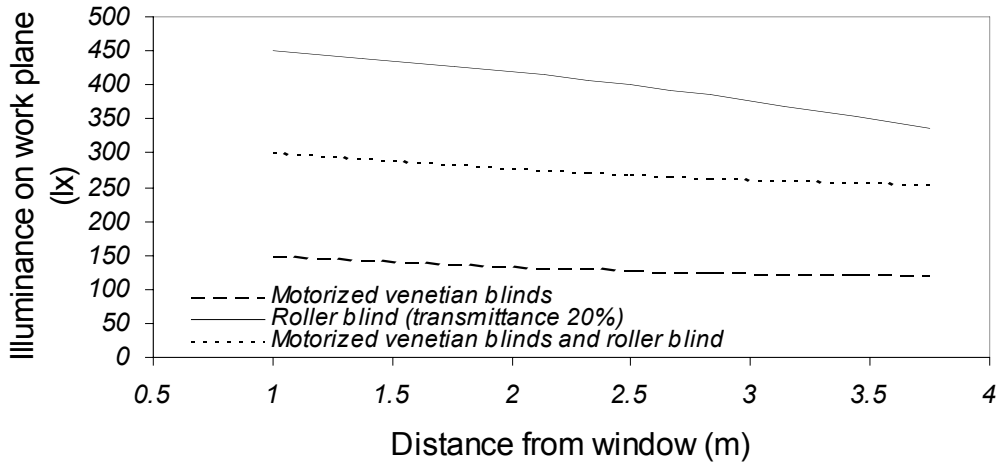

Figure 2. Illuminance distribution on the work plane for different shading devices, December 15th, 3pm, clear day.

The perimeter offices may also be used to illuminate adjacent spaces (corridors) with natural daylight, if back windows (single glazing) are placed on top of the back wall of the office (see Fig. 1). This will reduce electricity consumption for lighting in the corridors (as shown below) and create a pleasant environment during clear days, although corridors are not in the perimeter of the building. Since the illuminance distribution is known in the office, it is possible to find the amount of daylight incident on the back window and transmitted in the corridor, and then compute the illuminance distribution in the corridor. This is shown in Fig. 3 for the case of motorized venetian blinds and a roller blind on the exterior window. It is evident that in this case, the corridors are well illuminated and no artificial lighting is necessary. The corridor is assumed to be 3m wide.

2.3 Electric lighting options and energy savings

The electric lights are to be dimmed to provide adequate illumination on the work plane, when there is insufficient amount of natural daylight (set point is 500lx), so as to reduce electricity consumption. Simulations were performed to estimate the potential benefits of daylight utilization in conjunction with the motorized shading devices and light dimming.

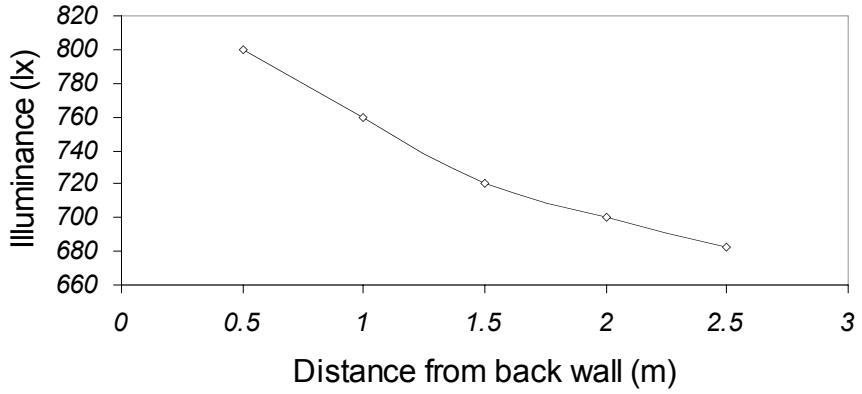

Figure 3. Illuminance in adjacent corridors, July 15th, 1pm, clear day.

For a typical office, three 60W T8 lamps with their 10W ballasts were assumed (12W/m^2 power). Two options were considered for electric lighting control: (i) continuous dimming of all lamps, 0%-100% and (ii) three-level control based on on/off operation of one, two and three lamps. Figure 4 shows the daily electricity consumption for lighting throughout the year for both options.

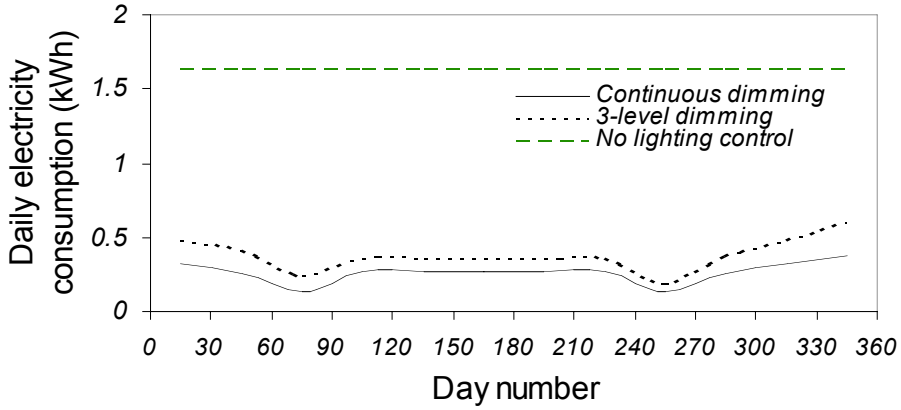

Figure 4. Comparison of electricity consumption with continuous dimming, three-level switching and no lighting control for a typical perimeter office on SW façade.

These calculations were performed for all facades, to estimate the total energy savings due to reduction in electric lighting for the perimeter offices (see Table 1).

Table 1. Yearly electricity savings (kWh) for the whole building perimeter.

Savings from:	Continuous dimming	Three-level control
SW façade	110000	90000
SE façade	61400	50000
NW façade	28200	23000
NE façade	74700	61000
Total in perimeter spaces	274300	224000

The advantages of dimming the lamps continuously are better visual environment and high energy savings (83%). Energy savings with the three-level dimming reach 70%. This option is more cost-effective and it was the one tentatively chosen by the administration.

2.4 Reductions in energy consumption for heating and cooling, and peak loads

Detailed transient thermal studies were performed for heating design days (cold cloudy and sunny) and for cooling design days (hot sunny) using software based on a MathCAD electronic book (Athienitis 1998). Solar gains, conduction gains, lighting and other internal gains are all taken into account and the results are based on detailed transient analysis. It was found that the motorized shading devices reduce dramatically the peak cooling loads and energy consumption. Cooling loads are further reduced because the lights are dimmed. Table 2 shows the impact of different options on peak heating and cooling loads and Table 3 shows the impact of the same parameters on the energy consumption. The heating analysis is for a cold cloudy January day, while the cooling analysis is for a hot sunny summer day.

Table 2. Impact of glazing thermal resistance, shading control and light dimming on heating and cooling peak loads (for perimeter spaces only).

Window R-value (RSI)	Peak heating load (kW)	Peak cooling load-no shading control, no light dimming (kW)	Peak cooling load-no shading control, light dimming (kW)	Peak cooling load-motorized shading devices & light dimming (kW)
0.52	1023	1431	1263	919
0.67	865	1405	1236	892
0.85	632	1386	1217	873

Table 3. Impact of glazing thermal resistance, shading control and light dimming on heating/cooling energy demand (for perimeter spaces only, interior zones not considered).

Window R-value (RSI)	Yearly heating energy demand (MWh)	Yearly cooling energy demand-no shading control, no light dimming (MWh)	Yearly cooling energy demand-no shading control, light dimming (MWh)	Yearly cooling energy demand-motorized shading devices & light dimming (MWh)
0.52	1023	1431	1263	919
0.67	865	1405	1236	892
0.85	632	1386	1217	873

As can be seen, there is no significant reduction in cooling load or energy consumption when window R-value is increased beyond 0.67 RSI, because most of the cooling is due to solar gains, lighting and other internal gains. The major reduction in required cooling capacity is obtained with motorized shading devices. Figure 5 compares the cooling load curves for all three cases during a hot summer day.

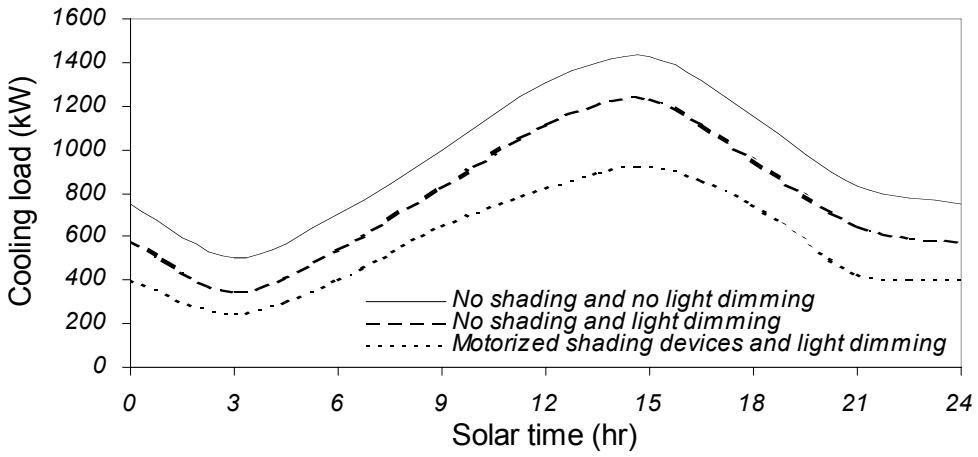

Figure 5. Cooling load during a hot summer day for the different cases of Table 2.

3. CONCLUSION

Major design façade options and associated energy simulation results were presented for the new Concordia University Engineering building. By choosing two thirds of the façade area to be glass with R-value 0.67 RSI, perimeter heating may be eliminated. Maximization of daylight is achieved by selecting clear glass for the facades.

The selection of shading devices and their control is particularly important; thermal and visual comfort, heating and cooling energy consumption are strongly affected by the type and control of the shading device used. The combination of motorized venetian blinds operated by the building automation system with a manually controlled roller blind in the lower portion of the window was an optimal solution; high daylight quality is achieved and peak cooling loads and energy consumption are significantly reduced. Motorized shading devices should be taken into account in sizing the cooling system (600 kW reduction).

Three-level light control in conjunction with the motorized shading devices leads to extra energy savings due to reduction in electricity consumption for lighting (260000 kWh for perimeter offices and adjacent corridors) and also due to reduction in cooling energy demand (170 MWh yearly).

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Various Aspects of Demolition and Recycling

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INTRODUCTION

Pilestredet Park, located in the centre of Oslo, is being transformed from a national hospital area of 70,000 m^2 into an ecological city residential area. Sixteen of the 32 buildings are to be demolished. This research project focuses on different aspects of demolition in general, in addition to the actual demolition process at Pilestredet Park in Oslo. The project consists of seven parts, but only the first four are presented here:

1. Recycling of prefabricated concrete building elements
2. Recycling of technical installations
3. Wooden roof constructions; material or energy recycling ?
4. Suspended particles and noise from small mobile concrete crushers
5. The demolition on Pilestredet Park
6. Management of demolition projects
7. Degree of specification necessary for the successful demolition tender

RECYCLING OF PREFABRICATED CONCRETE BUILDING ELEMENTS

For the last 20-30 years, prefabricated concrete elements as slabs, facades and columns have been widely used. Recycling of concrete (crushed) is increasing in Norway, though reuse of prefabricated concrete elements are still not common. The aim of the project has been to test if the reuse of elements can be justified both environmental and economical.

In this project we have focused on the reuse of prefabricated concrete slabs from a six floor building built in 1989. The prefabricated concrete elements were mounted onto a steel-superstructure, and it was approximately 200 m^2 prefabricated elements in each floor. Each element was approximately 15 meters long and weighed 10 tons.

We tried to reveal the actual building method and the matching details. Access to drawings with details of the anchoring methods made it easier to plan the dismantling. If the dismantling is too time consuming, the reuse will not be profitable. Anchor method and accessibility to the anchor points are therefore essential for the success of element reuse.

The elements in the project were anchored through the reinforcement steel, welded to the steel structure and then embedded in concrete in each end of the elements. This is a very common method for anchoring slab elements. To loosen them, we had to use a mechanical hammer to remove the embedded concrete, and cut the reinforcement steel. The accessibility to the anchor point of the elements were good for six out of ten elements in each floor. In other buildings access to this anchor points can be a problem.

Obviously it is essential to avoid irreversible damages to the elements when dismantling them. The critical moment is when an element is loosened and lifted from the structure and placed on a truck. The most effective method for this operation would be to use the mobile crane to loosen the elements, as you would need a mobile crane to lift the elements onto the truck anyway. To lift away the element from the structure you have to be able to put ropes,

yokes, or special designed lifting equipment around the element. For this operation the element can not be in contact with its neighbour element. In this project we did not plan to transport the element from the structure, so we just used an excavator to loosen it and to move it sideways on the structure so that it was no longer in contact with its neighbour element.

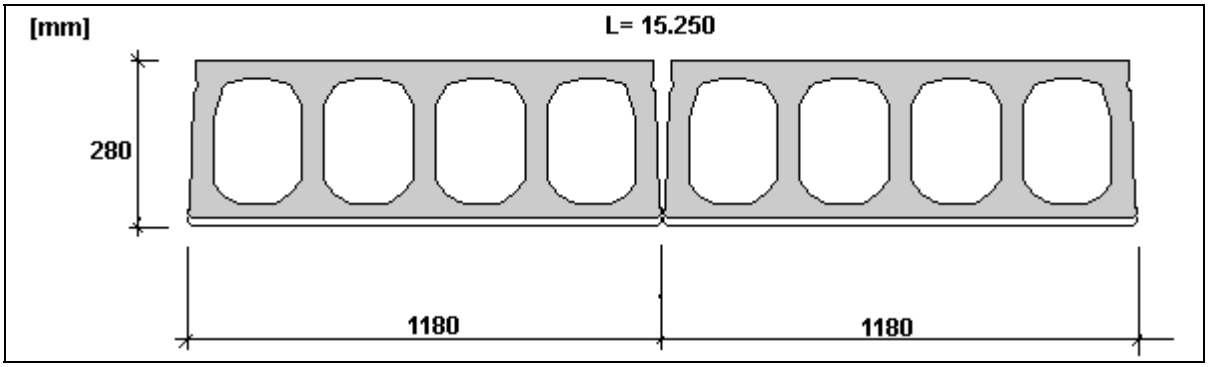

Figure 1 Actual concrete slab elements with dimensions

Technical installations like ventilation ducts were partially integrated in some of the elements, and made these elements unsuitable for reuse. Other elements were difficult and time demanding to loosen because of the way they were anchored. In this project we did not use any special designed tools, though sufficient tools for deconstruction of prefabricated concrete elements exist. Having access to such tools would make the deconstruction easier and faster.
At the end of the project we experienced nevertheless that prefabricated floor elements are said to be reused in a small scale, and in small buildings. Demolishing for storage of the elements would, due to the costs for unloading, storing and reloading the elements, probably not be profitable. Therefore the entrepreneur have to know if he is able to sell the used elements or not, when an element building is to be demolished. Providing that the buyers do not have a tight schedule for their projects, the buyers should in advance roughly specify what kind of elements they need, and then wait. A big market gives secures a short waiting period. All responsibility for the elements have to be undertaken by the buyer at delivery.
Some years ago there were other building regulations and material requirements, hence a problem with large scale reuse of prefabricated elements could be the re-certification. An important question is: “Are professional contractors or construction companies willing to guarantee for the quality of these reused elements?” Another challenge is that there are different ways of assembling the elements onto the structure. To make it profitable, planning, dismantling and deconstructing can not be too time consuming.
Logistics are probably a key issue for reuse of prefabricated concrete elements. To make reuse common in large scale there is a need for infrastructure for such reuse. It is though to believe that reuse of prefabricated concrete elements saves energy and raw materials, and sometimes money, and that this will increase reuse in the future.

RECYCLING OF TECHNICAL INSTALLATIONS

Modern buildings have a large amount of technical installations for lightning, heating, telephone, computers, elevators and escalators and so on. Many of the installations are renewed or renovated several times during the life cycle of a building. When the building is to be demolished some installations still have a long remaining lifetime.
The project intended investigating several technical installations for reuse. A prior feasibility study for a “recycled house” – a building built with a great deal of used building materials – planned on Pilestredet Park, revealed that some installations probably were more suited for reuse than others.

In that project we revealed that there are some major challenges in demolition for reuse, like

- to dismount the products properly and secure all parts (like brackets)
- to pack the product properly to avoid damages
- the logistic process; transportation for storage, storage itself, transportation to the building site
- if an external technical or visual renovation is necessary, the logistic in cooperation with that process comes in addition
- to install the products properly (this needs some goodwill from the craftsmen)

In addition to the challenges mentioned above the main challenge when reusing technical installation is the manufacturing responsibility /product liability. Due to the complexness of such installations, this is more difficult than for building materials. The importance of this is related to the quality of the installations when they are installed in a new building. The quality of the installations says something about the probability for failures. Failures in technical installations like electricity or plumbing could cause consequential damages like fire or water damaged building materials. This is of vital interest to the insurance company.
Based on the knowledge from the feasibility study we decided to take a closer look at cable ladders (not presented), ventilation aggregates (not presented), radiators and elevators.
Radiators are relatively easy dismountable, handy and able to resist rough handling. They are exposed to corrosion when they are drained. Prior reuse often showed that corrosion, sand and dirt tended clogging valves and other narrow passages in heating systems. This led to mal-functions even after flushing the heating system. The attitude among engineers who design heating systems, is to use new installations, like new radiators.
An elevator represent another high cost technical installation. Elevators are long lasting technical installations and due to the safety regulations most of them are well maintained. The different units of an elevator, like the car, the electromotor, the wheels and control unit can all be reused.
The recycled house was to be built in six floors, and needed an elevator. Considerable effort was made select an elevator which had the right size and a good technical standard. A survey with professionals led to the result that all elevators had some good parts, and that it was possible to build a new elevator out of used parts from different elevators in the hospital. An elevator built in 1982, which was in good condition, was chosen as the main part of “the recycled elevator”.
In 1995 the ECE directive (95/16/EC) on the approximation of the laws of the member states relating to lifts, was legislated. The directive increases the level of safety by adding several new demands, e.g. the safety parts had to have the CE-mark. This mark means that they are produced according to the regulations concerning health, environment and safety. Most of the parts in e.g. a 10 year old elevator are not CE-marked. To reuse such parts, they have to be upgraded and controlled by a specially approved institution. The costs for such controls are high.
Due to financial problems the construction of the recycled house has not started. Nevertheless has this project revealed that it is possible to reuse old elevators in new buildings. Due to the legislation though, reusing an elevator probably would exceed the price of a new elevator by two to three times, and is therefore not economical efficient.

WOODEN ROOF CONSTRUCTIONS; MATERIAL OR ENERGY RECYCLING ?

Wood is a widely used material in roof constructions in Norway. Some of these wooden roofs are of good quality when demolished, and can be reused as building materials. A study is made in order to evaluate whether it is economically and environmentally beneficial to dis-mantle these constructions for material recycling or to demolish them for energy recycling.

In order to detect the most economical beneficial method to handle the roof, there were a number of activities that needed to be explored. Some of the challenges and questions that had an impact on the choice of demolition method are listed below:

- The number of stories in the building. Is it necessary with working scaffold or crane to dismantle the constructions and transport the materials down?
- Purity of the materials. Are there nails and other extraneous matters that needs to be removed, and how time consuming will this be?
- How are the constructions assembled, and what equipment/machinery is available for the dismantling?
- Is there a market for these materials, and at what price?
- Progress. Dismantling of the construction demands additional time. How will this affect the time schedule?
- Re-certification or product liability. Who are willing to guarantee for the quality of used materials (decay)?
- Logistics. Accessibility and location of the building/construction site, availability and need of storage etc.



Figure 2 Dismantling of the wooden roof construction.

The building examined was built in 1883, but the roof construction was built in 1927. The building consisted including the attic, of five floors. The roof construction consisted of trusses of wood, wooden panelling, roofing paper and roof diaphragms of steel. Most of the attic were used for storage, and had boots with wooden panelling on both sides. The attic's concrete floor made it possible to use a small excavator (1.4 tons). Other tools used were crowbar, saw, chainsaw and spanners.

Since dismantling and removing nails and other extraneous matters would be too time-consuming for the wooden panelling, we focused on reuse of the trusses and similar large dimensioned materials. To make the comparison as good as possible, only the western- and the eastern part of the roof were part of the project. Each part was 35.5 meters long and 16.8 meters wide. The western part was dismantled / demolished for energy recycling and the eastern part were dismantled for material reuse.

The dismantling-/demolition crew used approximately 30 % more time on the western part of the roof than on the eastern part. This was an unexpected result. The reasons given were that they started on the western part, and therefore needed some extra preparation time, e.g. for security preparation and to cut a hole in the roof to get the excavator in. There were also more ventilation aggregates and remains of earlier ventilation systems on the western side that limited the workspace for the demolition-/dismantling team. Even though the use of the excavator were more extended on the western part, there were a lot of similar work to be done. The roofing paper and roof diaphragms had to be removed in both sides first.
When the bolts were removed, there were not much extraneous matters left in the wood for reuse. To transport the wooden constructions for reuse to the ground, a mobile crane was hired. The time-, and cost for this operation is not calculated here.
Material reuse of wooden constructions in Norway will probably never reach a large scale. The craftsmen are too expensive and wooden building materials are not very expensive compared to the costs for deconstruction.

SUSPENDED PARTICLES AND NOISE FROM SMALL MOBILE CONCRETE CRUSHERS

Demolition of most buildings produce a large amount of heavy building materials such as bricks and concrete. Reuse of these materials as they appear after the demolition is possible, but then only for filling of holes and other "unqualified purposes". Most kinds of reuse of these materials demand a homogenous material size. Therefore the materials are crushed to a specified size and non-homogenous elements like wood or steel are sorted out. The crushing can be done on the demolition area itself or in a larger "crushing plant", normally situated outside the city area. Local crushing of the main demolition materials concrete and bricks could reduce truck transportation in the city.
We have measured the level of noise and suspended particles from a small mobile crusher (Haahjem C-100). The crusher was fed with demolished bricks and concrete by an excavator, which was fed intermittently by a dozer. The products, crushed bricks (size 4 – 20 mm) and silt (0-4 mm) were taken away by the same dozer.

Noise

The noise measurements was done in December 2001. The crusher itself produces at full load a maximum sound power level (SWL) of 118 dB(A) re. 1 pW. Unloaded it produces a maximum SWL of 118 dB(A) re. 1 pW. The sound power level is not related to other factors than the measured object itself.At a distance of 10 meters the crusher and the excavator produces an average sound pressure level (SPL) of 82 dB(A) re. 20 μPa. At a distance of 25 meters the SPL is reduced to 76 dB(A) re. 20 μPa. The excavators contribution to the sound pressure level is very small.
The noise level of the crusher is at the same level as the machinery used for the demolition and the transport. Hence, the noise level produced by the crusher is not as high as assumed.

Suspended particles

Suspended particles were measured over a period of more than three months in the autumn of 2001. The measuring station with equipment was situated at the border of the park, 20-30 meters away from the crusher itself. A location any closer to the crusher was impossible to achieve due to the dozer traffic and the need for working space. In the measuring period the crusher was situated in three different places. The measuring station remained on the same place for the whole period. Two of the three crushing locations were more than 100 meters away, and the measurements from that period were estimated as irrelevant to the test, but relevant as basis of comparison.

An increase in the level of PM_{10} is measurable at a distance of 20-25 meters or more. The average PM_{10} in the relevant period (where the crushing takes place near the measuring station) is 33,3 μg/m^3, and for $PM_{2,5}$ approximately 10 μg/m^3. The source for the increase in suspended particles could be either the crushing or the demolition of buildings nearby, or both, but it is difficult to identify. A severe increase in PM_{10} is measured when the conveyer of the crusher is located only 13-14 meters away. After three months of measurements the conclusion is that some of the large fraction ($PM_{10-2,5}$) of suspended particles tends to fall to the ground within 25 meters, while the reduction in the fine fraction ($PM_{2,5}$), at that distance, is not obvious.



Figure 3 Mobile crusher at work

The Norwegian Pollution Control Authority (SFT) has defined the air quality criteria of $PM_{2,5}$ to 20 μg/m^3, and for PM_{10} to 35 μg/m^3. (While the national goal for the air quality in cities for PM_{10} is 50 μg/m^3). In the relevant period, the air quality criteria for PM_{10} was exceeded in 17 % of the time, while the criteria for $PM_{2,5}$ only was exceed one single day.
This leads to the conclusion that the noise as well as the amount of suspended particles from a mobile crusher seems acceptable at Pilestredet Park, especially when having in mind that it works on an area, where the level of noise and suspended particles are, due to the demolition, higher than normal. The crusher was in this period not connected to any water supplies. Spraying with water in the crushing chamber could in all likelihood have reduced the amount of suspended particles.

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Towards Sustainability in the Residential Sector
A Study of Future Energy Use in the Norwegian Dwelling Stock"

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1. INTRODUCTION

The power production in Norway has traditionally been based on hydro electric power. Good supply and low prices of electric power have stimulated the installation of electric heating systems, and direct electric heating dominates in residential houses. The energy and electricity use is steadily increasing, especially in the residential sector, and today, Norway has the highest electricity use per capita in the world. But, Norway is now facing a situation where hydropower cannot cover the increasing power demand. Instead, electric power produced from fossil fuels must cover the increasing demand, involving large emissions of CO_2 and other environmentally harmful gases.

The steadily increasing use of electricity therefore represents a large problem when considering how Norway is going to meet the Kyoto obligations. According to these obligations, the Norwegian emissions of greenhouse gases shall not be more than 1 % higher between 2008 to 2012 than in 1990. In 2001, the total emissions of greenhouse gases were 8 % higher than the 1990 level. The current development indicates that the emissions will about 20 % higher in 2010 than in 1990, and even higher if the planned gas-fired power plants are being constructed.

The scope of the work presented in this paper has been to analyse the energy use in the Norwegian dwelling stock towards year 2030, and to study how it will be affected by alternative energy efficiency measures carried out in the dwellings. By focusing on future energy and electricity use in the residential sector, the report addresses a key issue on the way towards sustainable development.

2. ENERGY USE IN THE NORWEGIAN DWELLING STOCK

Dwellings represent about two thirds of the total floor area in the Norwegian building sector. The annual use of electricity in the dwelling stock is about 36 TWh, which is almost one third of the total electricity production in Norway in a standard year. Statistics Norway has analysed the evolution of the total energy use and floor space in the building stock from 1950 to 1990, and found that the total energy use increased proportionally with growing floor space in the building stock (Bartlett, 1993). It was also found that the increasing energy use had been covered up by using more electricity.

Growing floor space has been an important reason for the increasing use of energy and electricity in Norwegian dwellings. Table 1 shows the development in population, number of dwellings and total floor space in the dwellings stock from 1967 to 1995 according to household censuses conducted by Statistics Norway. The table shows that there has been a

strong growth in the total floor space, from 110 million m^2 in 1967, to 212 million m^2 in 1995. This growth has been caused by a significant shift towards smaller households and an increasing average size of the dwellings. Accounting for the increasing population, it is also found that the average floor space per capita increased from 29 m^2 in 1967 to 49 m^2 in 1995. This increase of almost 70 % is alarming from a sustainable point of view since it may be assumed to have counterbalanced the effect of all energy and resource efficiency measures carried out in the dwelling stock during the same period.

Table 1 Population in Norway in 1967, 1973, 1981, 1988 and 1995. Total number of dwellings and average floor space per dwelling from household censuses conducted by Statistics Norway. Estimated total floor space and average floor space per capita.

Year	Population	Number of registered dwellings	Household size	Average size of dwellings	Total floor space	Average floor space per capita
	Million	Million	Persons per dwelling	m^2	Million m^2	m^2
1967	3.79	1.23	3.1	89	110	29
1973	3.96	1.38	2.9	89	123	31
1981	4.10	1.52	2.7	98	149	36
1988	4.21	1.65	2.6	108	178	42
1995	4.36	1.89	2.3	112	212	49

3. CALCULATION MODEL FOR FUTURE ENERGY AND ELECTRICITY USE IN THE DWELLING STOCK

A calculation model has been developed at the Norwegian Building Research Institute for estimating the energy use in the dwelling stock towards year 2030 for different scenarios on the energy efficiency of new and existing houses.

The model divides the dwelling stock into three main groups of dwellings according to type of house (detached houses, divided small houses and large residential houses) and six sub-groups according to year of construction. For each sub-group, a stereotype of dwelling is defined, assumed to be representative for all the dwellings within the group. The total energy use in the stock is estimated by calculating the annual energy use per square metre for each of the stereotypes, aggregating with the total floor space in the group of houses they are representative for.

Table 2 shows the 18 sub-groups of houses included in the model, as well as the total floor space and calculated, annual energy use in the different groups per 31 December 1998. The calculated energy use in the stock is 48.5 TWh, whereof 68 % is used in detached houses, 19 % in divided small houses (row houses, small multi-family houses), and 13 % in large houses (terraced houses, block of flats). This shows that detached houses represent the single-most important group when considering the total energy use in the Norwegian dwelling stock.

Table 2 Dwelling stock model per 31 December 1998. Number of dwelling units, size of dwellings and total floor space. Calculated annual energy use per dwelling and per square metre, and aggregated annual energy use for the entire dwelling stock.

Type of house and year of construction	Dwelling units		Average size of dwellings	Total floor space[1]		Calculated energy use		Aggregated energy use	
	1,000 units		m^2	Mill. m^2		kWh/ dwelling	kWh/m^2	TWh	
Detached houses	**1,076**	**57%**	**130**	**140**	**67%**	**30,801**	**236**	**33.1**	**68%**
Before 1956	375	20%	124	46	22%	37,037	299	13.9	29%
1956 – 1970	231	12%	121	28	13%	30,008	248	6.9	14%
1971 – 1980	215	11%	137	29	14%	30,297	222	6.5	13%
1981 – 1990	184	10%	136	25	12%	22,727	167	4.2	9%
1991 – 1998	72	4%	161	12	5%	23,050	143	1.7	3%
1999 – 2030	-	-	-	-	-	-	-	-	-
Div. small houses	**431**	**23%**	**99**	**43**	**20%**	**21,257**	**214**	**9.2**	**19%**
Before 1956	118	6%	94	11	5%	26,568	281	3.1	6%
1956 – 1970	92	5%	103	10	5%	22,694	220	2.1	4%
1971 – 1980	87	5%	103	9	4%	20,289	196	1.8	4%
1981 – 1990	78	4%	103	8	4%	16,865	163	1.3	3%
1991 – 1998	56	3%	91	5	2%	15,231	168	0.8	2%
1999 – 2030	-	-	-	-	-	-	-	-	-
Large houses	**370**	**20%**	**74**	**28**	**13%**	**16,805**	**226**	**6.2**	**13%**
Before 1956	138	7%	75	10	5%	22,013	294	3.0	6%
1956 – 1970	105	6%	68	7	3%	14,071	207	1.5	3%
1971 – 1980	72	4%	79	6	3%	14,444	183	1.0	2%
1981 – 1990	32	2%	78	2	1%	12,641	162	0.4	1%
1991 – 1998	22	1%	81	2	1%	10,954	136	0.2	1%
1999 – 2030	-	-	-	-	-	-	-	-	-
Total stock	**1,877**	**100%**	**112**	**211**	**100%**	**25,851**	**230**	**48.5**	**100%**

Four scenarios are applied when calculating the energy and electricity use in the dwelling stock towards year 2030. These scenarios are:

- *Reference scenario* based on today's requirements in the Building Codes for new houses and limited improvement of the thermal performance of existing houses.
- *Improved energy efficiency scenario*, with slightly improved performance of new and existing houses.
- *High energy efficiency scenario*, with highly improved energy efficiency in new and existing houses.
- *Heat pump scenario*, with increasing use of heat pumps, but otherwise similar energy standard as in the reference scenario.

For all scenarios, the total floor space in the stock is assumed to increase from 211 million m^2 in 1998, to 291 million m^2 in 2030. The total number of dwelling units is correspondingly estimated to increase from 1.88 million units to 2.36 million units, and the average dwelling size from 112 m^2 to 123 m^2. The heat pump scenario assumes that heat pumps are installed in all new residential houses and gradually installed in existing houses. The other three scenarios do not consider any change in the way buildings are heated or the energy sources used.

Figure 1 shows the calculated total energy use in the dwelling stock towards year 2030 according to the four scenarios by type of energy (electricity and other energy sources). The reference scenario, based on a development similar to the current trend in Norway, shows a strong increase in the total use of electricity and energy. The energy efficiency scenario, in contrast, shows a strong decrease in the use.

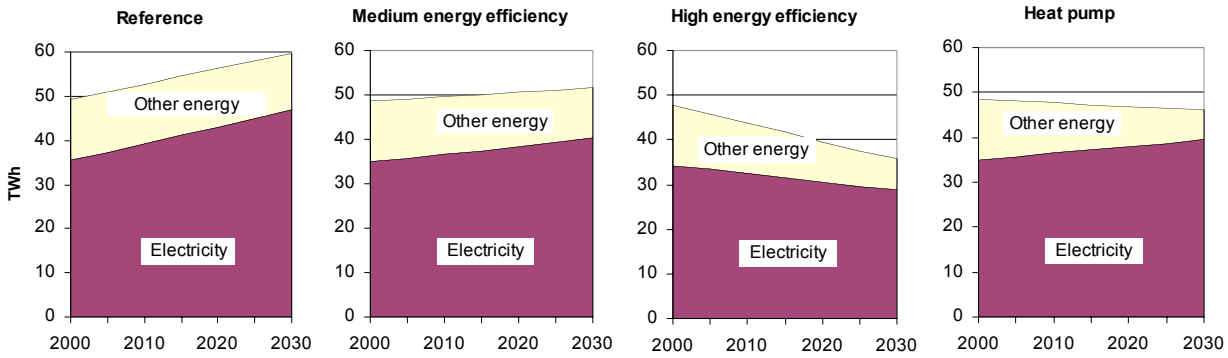

Figure 1 Calculated , total electricity use and other energy use towards year 2030 for four scenarios on the development in the average energy efficiency in new and existing dwellings.

Figure 2 shows more in detail how the calculated energy use in year 2030 is distributed on the different groups of houses. In all four scenarios, close to 70 % of the total energy use will take place in detached houses. The group of detached houses constructed before 1956, for instance, uses just as much energy alone, as all divided small houses together. It is also worth noting that detached houses constructed from 1999 onwards will represent a significant share of the total energy use in year 2030. The annual energy use of this group is several TWh higher for the reference scenario than for the other three scenarios. Large energy savings may therefore be achieved by constructing more energy efficient detached houses than common today.

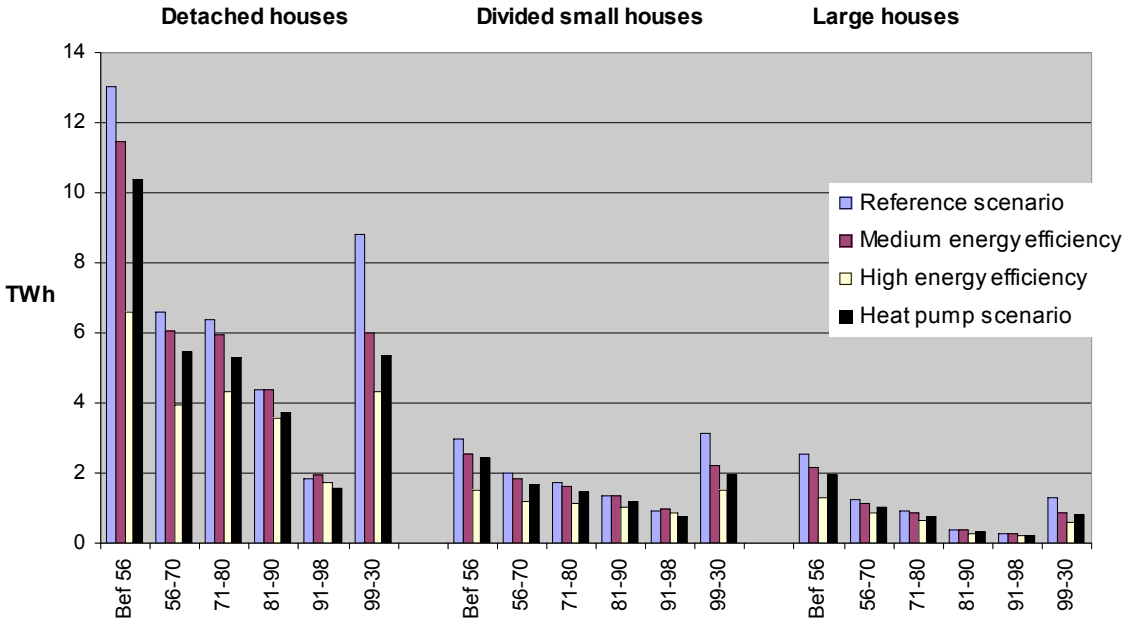

Figure 2 Total energy use in the dwelling stock in year 2030 by group of house and scenario.

4. HOW TO INCREASE THE ENERGY EFFICIENCY IN THE DWELLING STOCK?

The results presented in Figure 1 and 2 shows that it should be possible to stabilise and even reduce the total energy and electricity use in the dwelling stock in the future. But, this requires that the new houses are more energy efficient than the ones constructed today, and that appropriate energy efficiency measures are being carried out in most of the existing dwellings.

When considering how to improve the overall energy efficiency in the stock, it should be distinguished between the dwellings that will be constructed in the future and the dwellings that already are constructed.

For *new dwellings*, the most attractive way to improve the energy performance is by introducing stricter and more comprehensive energy requirements in the Building Codes. The prevailing codes only regulate the net energy demand for space heating and ventilation, not considering the energy use for lighting, electric equipment, fans, pumps, cooling and production of domestic hot water. It is a fact that space heating and ventilation only represent a minor part of the total energy use in modern, well-insulated buildings. New codes should therefore include a more holistic approach the energy use in buildings. An important initiative in this connection is the integrated energy approach in the proposal for Directive of the European Parliament and of The Council on the energy performance of buildings.

The Building Codes do not have a counteractive effect, and can therefore not be applied for *existing buildings* (except when major renovation works are being carried out). To influence the energy performance of existing buildings, a mix of economic instruments, information campaigns and education programmes instead should be taken into use. A main challenge is that the dwelling stock consists of almost two million dwelling units, most of them privately owned (78 %). To significantly influence the total energy use in the stock, a huge number of dwelling owners have to be persuaded to carry out energy efficiency measures. Many measures involve large investment costs and limited profitability for the owner. To improve the profitability, the energy improvement measures should be integrated as a part of the ordinary renovation and upgrading works regularly being carried out in buildings. The large number of dwellings constructed during the 1960s and 1970s, for instance, is facing a large need for renovation in the years to come. It should be an obvious goal to “piggy-back” energy efficiency measures as a part of the upgrading and renovation works that will be carried out in these houses in the future.

Increased energy taxes will make energy efficiency measures more profitable, and also contribute to increase the general energy awareness in the population. But, increased taxes is politically controversial and not easily accepted by the public. One way to get a larger acceptance for increased taxes might be to earmark the taxes for funding of energy efficiency measures. This way, the tax revenues will be given directly back to the house owners who are carrying out energy efficiency measures. Even a small tax increase would bring large sums of money that may be used for a funding program for energy efficiency measures. As an example: The yearly energy use in the dwelling stock is today close to 50 TWh. By increasing the average energy tax by for instance 0.05 NOK per kWh (0.6 Euro Cent per kWh), the total revenues for the funding program would be close to 2.5 milliard NOK per year. This is enough to subsidize 50,000 dwellings each year with 50,000 NOK (6,250 Euro) for investments in energy efficiency measures. Over a 30 years period, the programme would be able to subsidize measures in 1.5 million dwellings, or 75 % of the existing stock. The

increased tax revenues could also be used for financing soft-loans with lower rates for energy efficient renovation works.

Labelling schemes should be developed to inform about the energy performance of buildings and building related products. An important initiative in that connection is the previously mentioned EU directive on energy use in buildings proposing a mandatory energy certificate for new buildings and existing buildings that are to be rented or sold. This certificate shall provide information about the energy performance of the building.

Furthermore, general information campaigns about energy use in buildings and more targeted campaigns directed towards specific groups of users is needed to increase the energy awareness in the public. There is also a need to increase the knowledge and competence about energy use in buildings amongst the professionals in the construction sector (architects, engineers, contractors etc.).

Finally, there is continuously need for research and development of energy efficient solutions for buildings. The potential for developing more cost-effective solutions should be large, particularly if the solutions could be standardised and prefabricated. Demonstration projects should be actively used to test out and present the new solutions.

5. CONCLUSIONS

The total energy and electricity use in the Norwegian dwelling stock have been steadily increasing the last decades. Increasing floor space stock has been an important reason for this increase. There is a need to increase the energy efficiency in the stock to reduce future energy and electricity demand.

This paper has presented a calculation model for the future energy use in the dwelling stock, and calculated the total energy and electricity use towards year 2030 for different scenarios on the average energy efficiency of dwellings. The calculations show that it through energy efficiency measures should be possible to stabilize and even reduce the total energy and electricity use in the dwelling stock in the future.

A mix of regulatory measures, economic instruments, and general and targeted information programmes should be taken into use to realize the energy efficiency potential that exists in new and existing dwellings.

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Guidance for environmental assessment of building products

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1. INTRODUCTION

The environmental impact of products can be presented in an environmental declaration, which is a declaration that identifies and assesses the direct and indirect environmental effects of using the product, over its entire life cycle. If such declarations are used when deciding which building products should be used, the environmental load from building products can be reduced.

The construction and property sector in Norway is exhibiting growing environmental awareness. Private and public building owners have started to set environmental requirements in conjunction with planning, design, construction, operation, maintenance and demolition of buildings. Environmental `friendliness` has thus become a competitive factor for many companies in the construction industry. Unfortunately, only limited quantities of data for product groups or specific products are available, and little work has been done in order to assess the information.

To choose the most environmentally favourable product according to available product information, some guidance is needed as a help to interpret the data found in the declarations. To meet this demand, the Directorate of Public Construction and Property (Statsbygg) and the Norwegian Building Research Institute (NBI), have developed a simple guide. The guide was developed to identify building products with the lowest total environmental impact by nature of their environmental characteristics presented in environmental declarations.

The guide is intended to be used by manufactures, designers, architects and their clients, who typically lack environmental expertise. The guide is therefore based on applying some simplifications when the interpretations are made.

2. COMPARISON BETWEEN PRODUCT DECLARATIONS

Before comparing the products declarations, it is important to determine whether the declarations are comparable or not.

2.1 Functional unit

When evaluating solutions over an entire life cycle, it is important that the product has the same ‘functional unit’ in order to make the comparisons correct. A functional unit describes the qualities of the product over a given time period. This means that if two walls are to be compared, they must for example have the same U-value, sound absorbing, fire or load-bearing properties. In the product’s environmental declaration, the functional unit shall be given for the product’s principle function over the entire life of the construction, in other words from ‘cradle to grave’. This implies that chemicals or other products and processes

required for the maintenance, cleaning, replacement etc. must be included in the functional unit. A construction has a very long service life, sometimes as long as 100 years. The functional unit shall therefore be given for a corresponding period.

2.2 Product system and system boundaries

The life cycle of a product is a combination of processes related to production, use and disposal of the product. A product system is a collection of unit processes connected by flows of intermediate products, which perform one or more defined functions. The product system has a defined system boundary to other systems, which is the interface between the product system and the environment or other product systems. In order to enable comparisons between products, the environmental declarations must have approximately the same system boundaries (for example, some declarations include precombustion, some do not). It is also important to be aware of the phases in the product's life cycle that is included in the declarations, whether the declaration includes data from 'cradle to gate' or from 'cradle to grave'.

2.3 Data quality

The quality of the data in the declaration must be sufficient in order to fully represent the product. This is deficient in some declarations. In such cases, one must decide whether the poor data quality should be decisive for choosing the product. If both the data quality and the completing of the declarations are adequate, in the further assessment of the product's potential impact, the data in the declaration is assumed to be accurate.

2.4 Description of the environmental declaration EcoDec

Two environmental product declarations exist in Norway. One of these is EcoDec, an environmental declaration developed by at set of manufacturers of building products in Norway in collaboration with the Norwegian Building Research Institute.

The EcoDec declaration consists of both qualitative and quantitative information. The quantitative information is split into the following areas:

- data concerning product and manufacture information
- quality of the data in the declaration
- resources and raw materials
- environmental impacts
- waste management
- use of chemicals
- indoor environment.

The lifetime of a construction is set to 60 years.

The guide was developed mainly to work with EcoDec, but may also be used to compare products with other environmental declarations.

3. HOW TO USE THE GUIDE

The guide rates the relative importance of the various quantitative environmental data given in the EcoDec declaration. This consists of resources and raw materials, environmental impacts, waste management, the use of chemicals, and indoor environment. These five areas, including general data about product and its manufacture, and the quality of the data in the declaration, are assessed otherwise (see below). Figure 1 shows the priorities given to the

different the environmental areas, and is based on international agreements and national rules and regulations concerning environmental issues in Norway. These priorities also concur with Statsbygg's environmental policy. Other priorities can also be used if preferred.
Each area has a set of criteria that the products must fulfil, starting with a set of criteria for the indoor environment (deemed the most important area). The procedure involves comparing the products for each environmental area stepwise, according to the relevant criteria. The product(s) with the best environmental characteristics should fulfil the criteria for all areas.

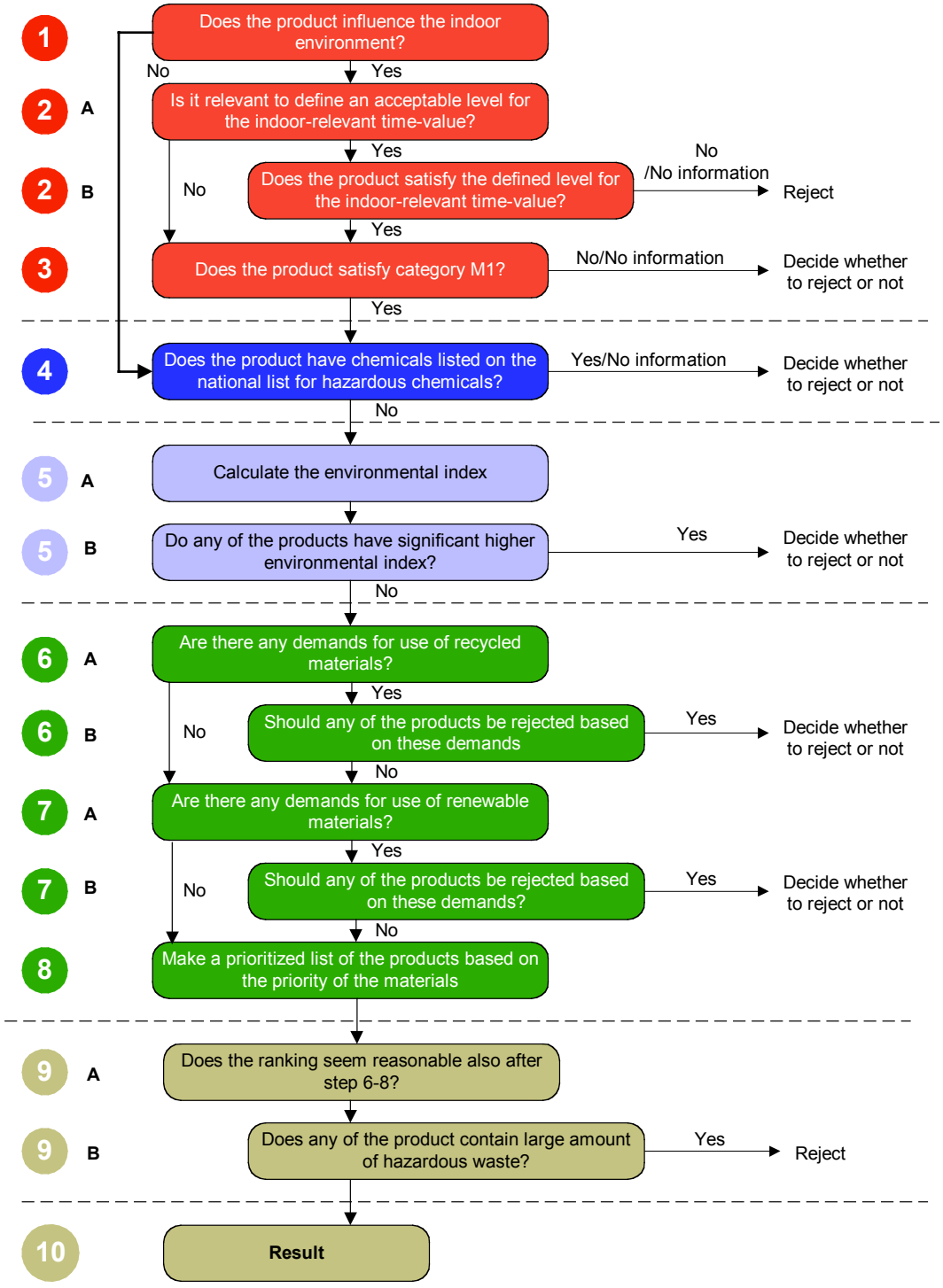

Figure 1 *10 steps to help prioritise different comparable products according to their different environmental loads*

3.1 Indoor environment

The steps for evaluating the product's impact on the indoor environment are illustrated in Figure 1 as the first three steps. Products such as surface materials, that can influence the indoor environment, are first evaluated due the indoor-relevant time-value. Also the quantity of the materials' total volatile organic compound (TVOC), formaldehyde, ammonia and carcinogenic compounds according to category 1 of IARC classification, are given in the declaration. They are classified according to CEN Report (CR) 1752, annex G with the categories M1, M2 and M3. Category M1 denotes materials that are known to be safe in respect of emission, such as brick, marble, ceramic tile, glass and metal surfaces. Category M3 includes materials that do not have emission data, or the emissions exceed the values specified for materials in category M2. The preferred material should satisfy category M1. Category M2 may be accepted in some cases, but should not exceed 20 % of the surface materials.

3.2 Chemicals

The State Pollution Protection Authority (SFT) in Norway maintains an 'OBS-list' containing hazardous substances (A and B list). The list contains substances that should no longer be used (or considerably reduced) in production of building products. The environmental declarations list the chemicals the specific product contains and in what quantities. If the evaluated product consists of substances listed on the OBS-list, one should decide whether to reject it in the further evaluation or not.

3.3 Environmental impact

In the EcoDec declaration, the environmental impact includes global warming, ozone depletion, acidification, formation of photo-oxidants and eutrophication, ecotoxicity and human toxicity. In this specific case, it is meaningful to aggregate the results from the impact categories, in order to evaluate the total potential environmental impact. This is done by normalizing and weighting of the categories. The normalization is done by emission per inhabitant, and the weighting of the environmental impacts is done by the Danish distance-to-goal method Environmental Design of Industrial Products (EDIP). The goals are defined Norwegian environmental aims for reduction of substances or groups of substances. Weighted together, the impact categories result in an environmental index that gives the total potential environmental impact. This index is used to compare the different products, since there is no defined limit that the index must not exceed.

3.4 Resources

Some simplifications have been made concerning evaluation of the data given under the area 'Resources and raw materials' in the EcoDec declaration. The use of energy in the production phase and demolition phase is normally considerable smaller in Norwegian buildings than the total energy consumption during the whole lifetime. The use of energy is therefore not evaluated. Nevertheless, the emissions to air caused by the energy use <u>are</u> included in the environmental impacts. The raw materials are prioritised as followed:

Priority 1: Recycled materials
Priority 2: Renewable materials
Priority 3: Non-renewable materials (abundant)
Priority 4: Non-renewable materials (limited)

3.5 Waste
The priority of handling of solid waste is due to known Norwegian goals, and waste to reuse/recycling is preferable. The next priority is waste to combustion for energy utilization and disposal. Hazardous waste is the least preferable type of waste, and if a large amount of such waste is produced (either under production of the product or if the product it self must be treated as a hazardous waste when demolished) then the prioritised list might be changed when it comes to the evaluation of hazardous waste.

3.6 Limitations of the guide
When evaluating environmental declarations by using the guide, it is assumed that the data quality given in the declaration is adequate. This may lead to some inaccuracy. For one thing, the lack of product specific data may affect the quality of the declaration. Furthermore, there is also a need for inclusion of uncertainty in the declarations, which is not yet the case in several environmental declarations. Maintenance of products is not yet included in many of the declarations and must therefore be included separately in the total evaluation of the various products. The simple electronic tool that can be used together with the guide does not, for the time being, include such maintenance, which makes the evaluations somewhat more difficult than if it included the maintenance. Maintenance should eventually be included in the tool.

4. DISCUSSION

4.1 Need for further development
The guide can benefit with further development in several areas.

For some of the environmental areas in the guide, there are no specific goals. In these areas the evaluated products are therefore merely compared with each other to ascertain which product has the lowest environmental load. Thus it is difficult to state which, if any, of the products have an acceptably low environmental load. Evaluation of the environmental impacts including global warming, ozone depletion, acidification etc. is one of these areas.

The guide has been primarily developed for the Directorate of Public Construction and Property, for use in their building projects. If the guide is to be adopted as a national method, the environmental index, at least, should be further developed. First of all, there should be national consensus on which weighting principles to use, whether the one presently used, or some other method.

There also is scope for increasing accuracy with respect to human toxicity and ecotoxicity, as these are not taken into account because of lack of emission figures and nationally accepted levels. Further development of the environmental index is therefore desirable.

Further, there should be gained enough knowledge of the environmental index for various groups of products to be able to establish a level of acceptance. If such level is known, it is possible to define specific demands for maximum accepted environmental index for a single product.

4.2 Experiences so far
Since its introduction early in 2001, the guide has been used to some extent in a few projects. Users report that the guide is easy to use, and that it helps in the understanding and interpretation of the environmental declarations when evaluating materials. A major problem

is the lack of declarations, and that the various products have declarations with various formats and are based on different system boundaries.

Architects claim that this method is still too difficult and that the burden of work is too high to be able to make practical use of the method in their work. However, the guide is a step towards increased knowledge and interest in choosing of environmental sound products, and increased demand for products with environmental declarations. As more declarations are published, there will eventually be enough knowledge about the environmental loads from products to be able to establish acceptable levels for all the environmental areas.

And if there are defined levels for all 5 environmental areas in the declaration, it will be possible to group products into various classes based in the environmental loads, in a very simple manner that architects and other planners can employ.

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Dynamic enclosure approach for a building as a power plant

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1. INTRODUCTION

A plus-energy university building called "Building As A Powerplant - BAPP" will be erected on Carnegie Mellon University campus till the end of 2004. Initiated by the "Center for Building Performance and Diagnostics – CBPD" this project aimes to an integrated research and design effort to develop an innovative energy efficient "state of the art" office building incorporating advanced building technologies (Mathew). The development of an office building implicates a bundle of multiple and complex requirements: e.g. concerning indoor air quality, visual and thermal environment as well as a minimized energy consumption.

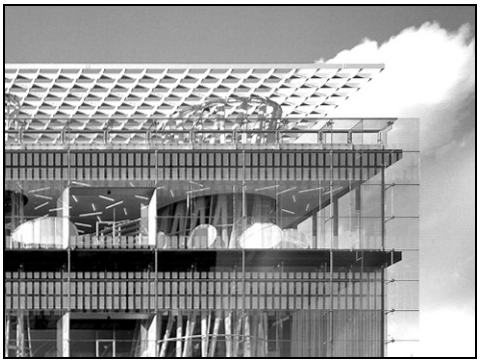

Figure 1 Facade Sendai Mediathek, Miyagi, Japan, Architect Toyo Ito, 2000

The collaboration within this research project was the occasion for us to rethink how the design of an office-building envelope can deliver a significant contribution to the fulfillment of these requirements. Newer trends in architectural design show an intensive search for newer possibilities of expression that unfortunately often remain purely decorative, see figure 1. Such esthetical criteria are not examined. This paper intends to contribute to a more constituting, logic development of enclosure design.

2. ANALYSIS

2.1 Definition of Enclosure

To evaluate possibilities of influencing human comfort parameter and energy consumption we want to define "enclosure": an enclosure is a space-creating element by defining an interior and an exterior each with dynamic conditions (Mueller), thus separating the microcosm form the macrocosm. Thereby the enclosure is influenced by these conditions and influences these. The primary function of an enclosure is to deliver a habitable microcosm for human beings maintaining human comfort. The desire is to do this at the least energy "consumption".

2.2 Aspects of human comfort

Human comfort consists primarily of thermal, visual, air quality and hygric related aspects. Less dominant aspects include noise, vibration etc.. Newer research points in the direction that humans feel comfortable if these values vary dynamically similar to natural fluctuations (Fleischer). For each of following comfort aspects a certain corridor of values exists in which humans feel satisfied with their environment:

Thermal comfort: air temperature, radiation temperature of surrounding surfaces, air velocity, humidity, etc.

Visual comfort: illumination, luminance, reflectance, glare etc.

Air quality: air exchange rate, air exchange effectiveness, air composition, etc.

2.3 The enclosure's membrane potentials

Some aspects of human comfort cannot be provided artificially in the same quality compared to the outside (e.g. daylight) or/and require extensive energy input when established artificially. Consequently the enclosure should not define a non-penetrable border simply maintaining human comfort; moreover it could serve as a membrane/filter allowing those conditions in the range of human comfort to penetrate from the exterior in order to save energy use.

3. DEFINING A DYNAMIC ENCLOSURE

We assume that the enclosure as controlling filter has the potential to actively realize comfort issues to a significant extent. In order to refine this thesis, we first describe the media, which have the potential to penetrate the facade. In a second step we examine the gradient potential between micro- and macrocosm. Finally we explore the regulation and the utilization of the flows between dynamic exterior and interior.

3.1 Enclosure reaching and penetrating media

Air is composed of various gases and contains water vapor and particles. Its physical properties can be described by temperature, velocity, humidity and concentration of its particles and gases. Air is an indispensable necessity to human life in form of breathing air.

Solar radiation comprises multiple physical properties concerning light and energy. Light is that part of solar radiation which is "visible" for the human eye (380-780 nm). Long wave radiation determines a transport of energy that is perceived as warmth, short wave radiation incorporates UV irradiance with its related side effects.

Certain aspects of specific comfort targets such as air quality and illumination could be reached by simple air and light penetration through the building envelope. Other targets such as temperature and humidity in contrast are properties of either air or solar radiation and in some cases properties of both: e.g. temperature can be transported via convection (air), radiation (surfaces) and conduction (masses), humidity is a physical value that can be transported via convection and diffusion e.g. through walls (see figure 2).

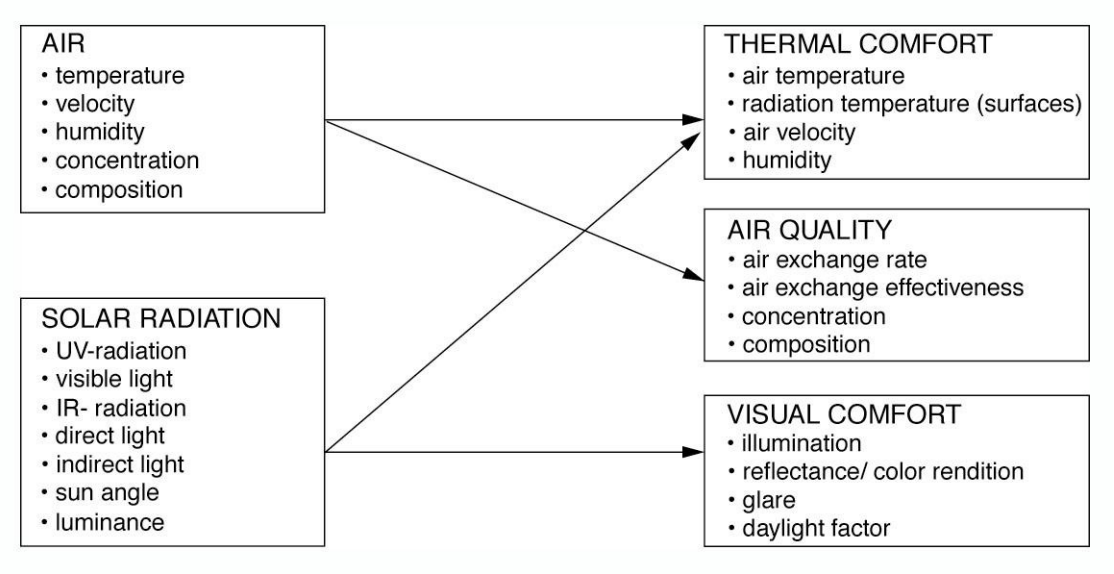

Figure 2 Interrelation between environmental offers and comfort targets

3.2 The gradient potential between macrocosm and microcosm

The gradient between the ex- and interior can consist of a difference in density (e.g. humidity), in a difference of energy potential (temperature) or in velocity (wind) etc.. The enclosure as a membrane preserves the potential difference, which embodies the effort to equalize. This flow occurs from the higher to the lower level, which can be either in the interior or in the exterior, and therefore possesses a direction. The existing gradient inducing flows offers the potential of regulation and utilization. For a potential use of these flows it is important to know their constant dynamic (due to the nature of the dynamic exterior and interior conditions) supported through experience and expert prediction.

If higher potentials are welcome to establish human comfort and/or save energy in their existing form they can be allowed to penetrate the enclosure. If not, they can be reflected, retarded, blocked or exploited for secondary use or storage.

If the flow of potential is desired or inevitable, but associated with properties out of the range of human comfort, these physical properties of the flow can be influenced through energy input or extraction

The effects of the above mentioned flows are “zone-dependent”: the location of the enclosure between the macrocosm and the building interior determines (without artificial enhancement) a decline of measurable effects and their intensities with increasing distance to the point of entry. This can result in excess supply of benefits close to the enclosure and an insufficiency in proximity to the core of the building.

3.3 Regulation processes of an enclosure

The reflecting, retarding, blocking or exploiting these flows through the facade between interior and exterior with/without energy input can be divided into three categories: “selection”, “modulation of concentration” and “transformation”. The knowledge of these categories is an important step towards designing a dynamic facade.

Selection - the enclosure has the potential to select a component from the entity of all outer climate components and to allow it’s penetration, e.g. it can allow daylight penetration but at the same time reject wind and rain. The selection process can occur within one component itself selecting physical properties (e.g. light: direct and indirect).

Modulation of concentration - components can be influenced/modulated regarding their concentration and/or intensity during the passage through the enclosure.

Transformation - the enclosure has the potential to alter a component concerning its state of aggregation (e.g. from gas to liquid) and to pass on physical properties of one component to another (e.g. solar radiation absorbed by thermal collector).

In the process of achieving human comfort and/or saving energy individual physical properties are always primary targets. These are always related to a component and therefore are linked to all other physical properties of that specific component. For further analysis we distinguish between primary effects and secondary effects, which have primary and secondary potentials (see figure 3).

- **Primary effects** are the desired result of targeting certain physical properties to achieve individual aspects of human comfort.
- **Secondary effects** are those caused by all other physical properties that are associated to the component that is carrier of the desired physical property.

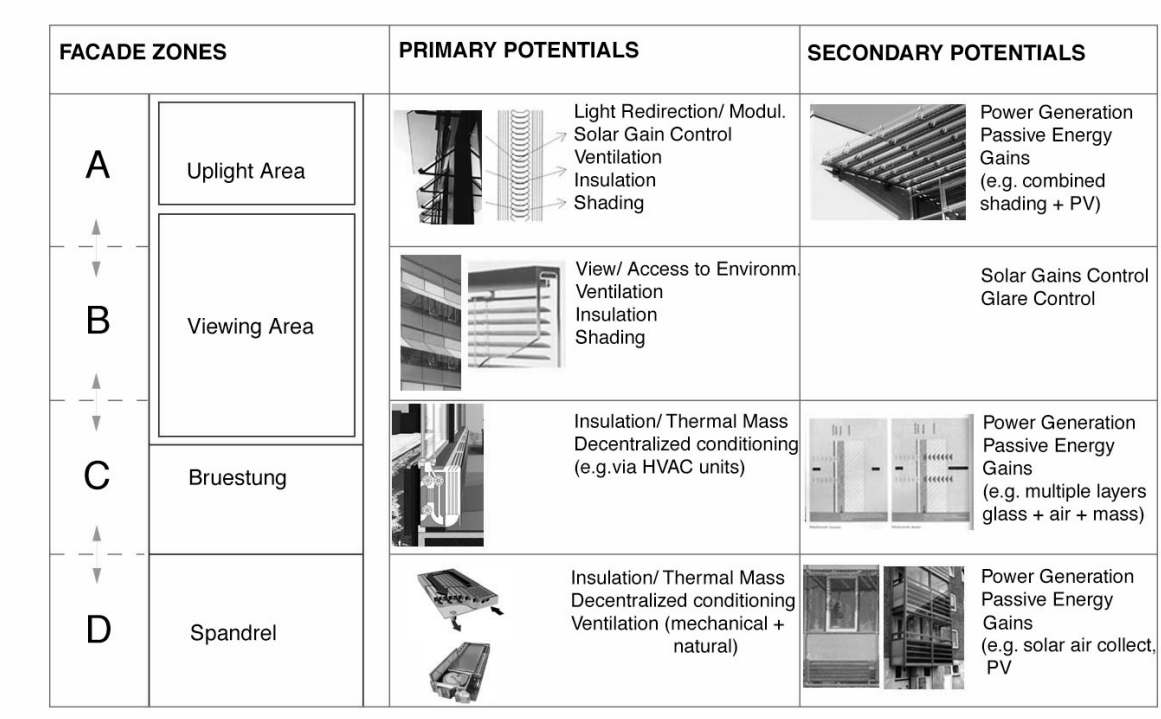

Figure 3 Facade zones and their potentials

3.4 Regulation via the three categories

From a historic view the transport of desired properties and components often were bundled in one and the same channel, which often implicated the above-mentioned unwelcome secondary effects. E.g. a loophole in a castle transported air and light, particles, noise etc.. A simple glazing of the eighties of the last century simultaneously transported light and heat. Today glazings are able to allow high visible transmittance and at the same prevent a significant portion of solar heat radiation in the near infrared spectrum from penetrating. The level and exactness of regulation processes attributed to the enclosure (selection, modification of concentration, transformation) can be enlarged by concentrating on one desired property

controlling (e.g. separation of light through glazed areas from ventilation through opaque openings) and/or influencing their temporal and vector-related properties, as all processes of regulation are time and direction sensitive.

3.5 Summary of Analyses

Establishing human comfort by means of the enclosure under the premise of lowest possible energy use presents a complex structure of interdependencies. Regulation processes must be fine-tuned in such a matter that they allow precise manipulation of the desired primary effects and ideally a counterbalance/exploitation of secondary effects on human comfort issues and energy aspects. Furthermore the regulating processes of the enclosure must have the capability to respond in accordance with the dynamic gradient of potentials and therefore the enclosure must be 'dynamic'. The definition of a dynamic enclosure in this context accomplishes:

- a dynamic regulation of all energy and matter flows that penetrate the enclosure due to the gradient of concentrations and their potentials
- an enclosure based energy transformation and their decentralized distribution.

The deduction of these requirements was done under the focus of addressing the enclosure as the primary location of regulation. This was done under the assumption that the enclosure allows a decentralized and immediate balancing of interior conditions in relation to exterior ones. The enclosure has the potential to regulate influences directly at their point of entry or exit and therefore allows immediate 'acting' on the inner climate of buildings rather than internal HVAC systems that are merely 'reactive' and therefore not as precise.

4. FIRST STEPS TOWARDS PLANNING DYNAMIC ENCLOSURES

4.1 Determination of overall requirements

Requirements have to be composed for a specific building with a specific use in a specific environment under the following premises:

- Prevention of energy consumption, delivery of remaining energy demands by maximized use of renewables and minimized energy "consumption"
- To realize these overall goals, the potential of the enclosure influencing the interior within all human comfort determining factors should be maximized.
- A corridor of tolerable values for human comfort requirements should be established allowing a dynamic modulation instead of defining specific values
- User override and influence on regulation processes has to be accepted as an important aspect of human comfort (which requires a "tolerant" building).

4.2 Developing an integrated model

First step: clarifying interdependencies

of primary and secondary effects associated to media and energy flows with regulation processes etc.. The goal is to

- develop innovative and more precise regulation mechanisms and dynamic measures
- create a basis for judgment to which extent these should be dynamic in terms of effect on inner building conditions as well as significance and necessity /feasibility.

Second step: an iterative process via simulation tools

has to determine the effects of step one. Step by step dynamic processes of modulation within the enclosure must be introduced and their effects on energy effectiveness and human comfort must be analyzed with adequate simulation tools (Oetzel). The results of those measures of

'active regulation' have to be evaluated in the light of foregoing definitions of performance specifications that can only be defined within corridors and not in form of specific values.

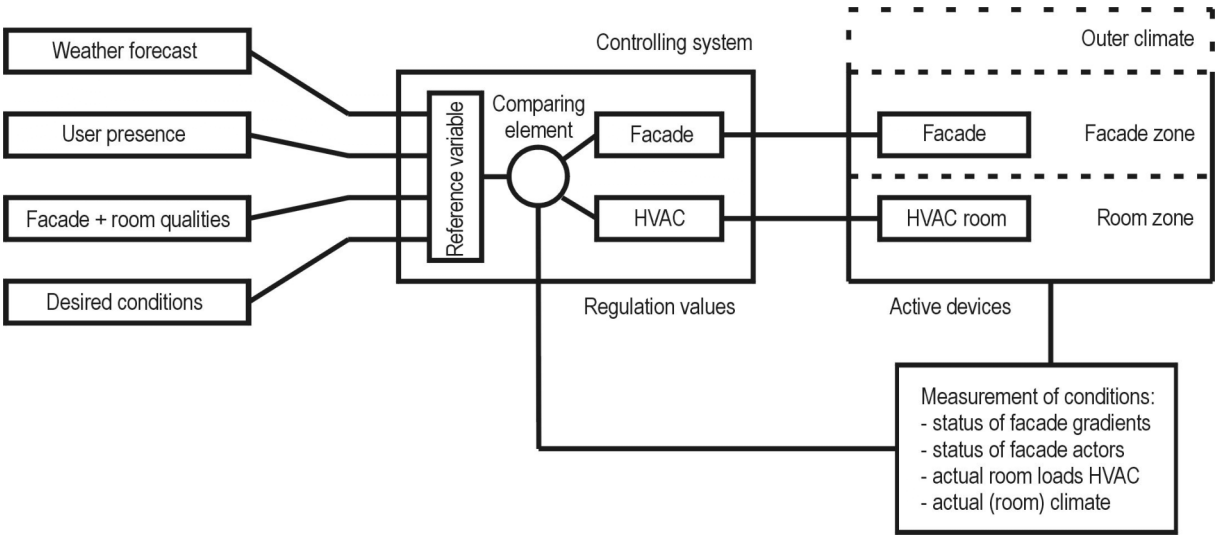

Figure 4 Integrated regulation model for a dynamic facade

Third step: balance with building and HVAC
During this process, the feasibility of building/HVAC systems and those making an enclosure dynamic must be balanced and coordinated. Two questions must be answered: What all must be dynamic and where does it makes sense? Especially the growing together of enclosure based HVAC systems with internal ones is of great importance.

5. SUMMARY/OUTLOOK

A dynamic facade has the potential to compensate geometrical imbalances as well as the partly unwelcome secondary effects related to the distribution of light, air, temperature and humidity through time- and direction sensitive regulation processes. Further research work has to be undertaken for future enclosures that should allow a more specific modulation of the interdependent issues.

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A National Rating System (LEED™ 2.0) as a Source of Benchmarks and Data for GBTool

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1. INTRODUCTION

This investigation explores how the primary national green building rating system used in the United States, LEED™ 2.0 (Paladino Consulting, 2001), might facilitate the performance assessment of U.S. building projects with the international environmental performance assessment framework GBTool (Natural Resources Canada, 2002).

GBTool is a comprehensive, generic building environmental assessment framework created through an international collaborative effort. After regional customization, GBTool assesses a building's environmental performance relative to its local context. At the same time, GBTool allows for international comparison through a set of absolute environmental measures. GBTool is organized as a series of electronic worksheets comprising data input and output. The input requires regional information and design data, and the output generates scores and other results.

LEED encompasses a diverse, performance-oriented compilation of prerequisites and point-earning credits. Certification of a project is determined by the fulfillment of all prerequisites and a minimum number of credits. Prerequisites and credits pursued must be documented. Credits that are not pursued are not reported in the documentation for certification. For the purpose of this discussion, prerequisites and credits are collectively called "targets," and the project documentation is called "LEED data".

The growing number of LEED certified projects in the United States combined with increased market acceptance of LEED as an industry standard has generated interest in the international comparison of the environmental performance of these LEED certified projects. This investigation explores regional customization of GBTool in the United States from the LEED rating system itself and the feasibility of taking U.S. projects from a LEED certification to a GBTool assessment. Consequently, this research implies a methodology to examine any green building rating system for its usefulness in assisting a GBTool assessment.

2. THE ROLE OF TEAMS IN A GBTOOL ASSESSMENT

The GBTool environmental performance assessment encompasses a well-orchestrated process of gathering information and entering data into the network of spreadsheets. The group of people in charge of coordinating this process is the assessment team. The design team provides project-specific data, and one or more panels of experts establish the pertinent regional information. This study calls the panels of experts "regional teams".

3. REGIONAL INFORMATION: FROM LEED TO GBTOOL

The regional teams give information for the following spreadsheets: Urban, Neighbourhood and Site Context; Voting for Weights; Energy Generation and Consumption Report; and Benchmarks. The Urban, Neighbourhood and Site Context worksheet requires specific information about the physical background of the project. The design team might also contribute data to this worksheet, since some LEED targets contain a great deal of context data. In the Voting for Weights worksheet, weights are assigned to some or all of the performance assessment issues to rate the relative importance of their components. The LEED system rates all targets equally; therefore, it does not contribute to this worksheet. The Energy Generation and Consumption Report is drawn from information about the primary energy generation and use in the region. Again, the design team might contribute some data to this worksheet, since some LEED targets require an energy simulation. The Benchmark worksheet is used to establish regional baseline values for the items considered by the tool. The Benchmark worksheet constitutes the center of this discussion, because of the potential for the LEED rating system to provide information for it.

3.1 Benchmarks

Benchmarks are defined in GBTool as "equivalent to the minimum acceptable industry practice in the region for class and type of building" (Cole and Larsson, 2002), established through regulatory standards, or by the consensus of regional experts. Benchmarks are organized by category and only their values are generated on a regional basis, whereas their subjects and units of measure are pre-defined in GBTool. This part of the study suggests a methodology to review the LEED system itself for possible assistance in establishing benchmark values.

3.1.1 Type and Class of Building. LEED is designed to rate commercial occupancies, institutional buildings, hotels, and residential buildings of four or more habitable stories. GBTool is used for the assessment of office buildings, school buildings, and multi-unit residential buildings. Therefore, a GBTool benchmarking process for the types of buildings addressed in both LEED and GBTool may be possible using LEED-provided information. LEED does not address class of building.

3.1.2 Subjects. LEED subjects significantly overlap those addressed by GBTool. GBTool benchmarks and LEED targets are sorted into categories which somewhat correspond and cross over in several instances. In Figure 1, the GBTool benchmark subject is marked as *analogous* if it is addressed, at least partially, in one or more LEED targets. The overall result of this comparison is that 72 of the 102 GBTool benchmarks approximately address the same subjects as 66 of the 71 LEED targets, a substantial correlation.

3.1.3 Regional Building Practices. LEED is published for the United States as a whole, although it includes occasional alternates for specific parts of the country. GBTool does not define what constitutes a region. However, regulations, practice and climate are distinct enough in portions of the U.S. that regions are defined. LEED requirements might need further regional adaptation to provide GBTool with relevant benchmarking information.

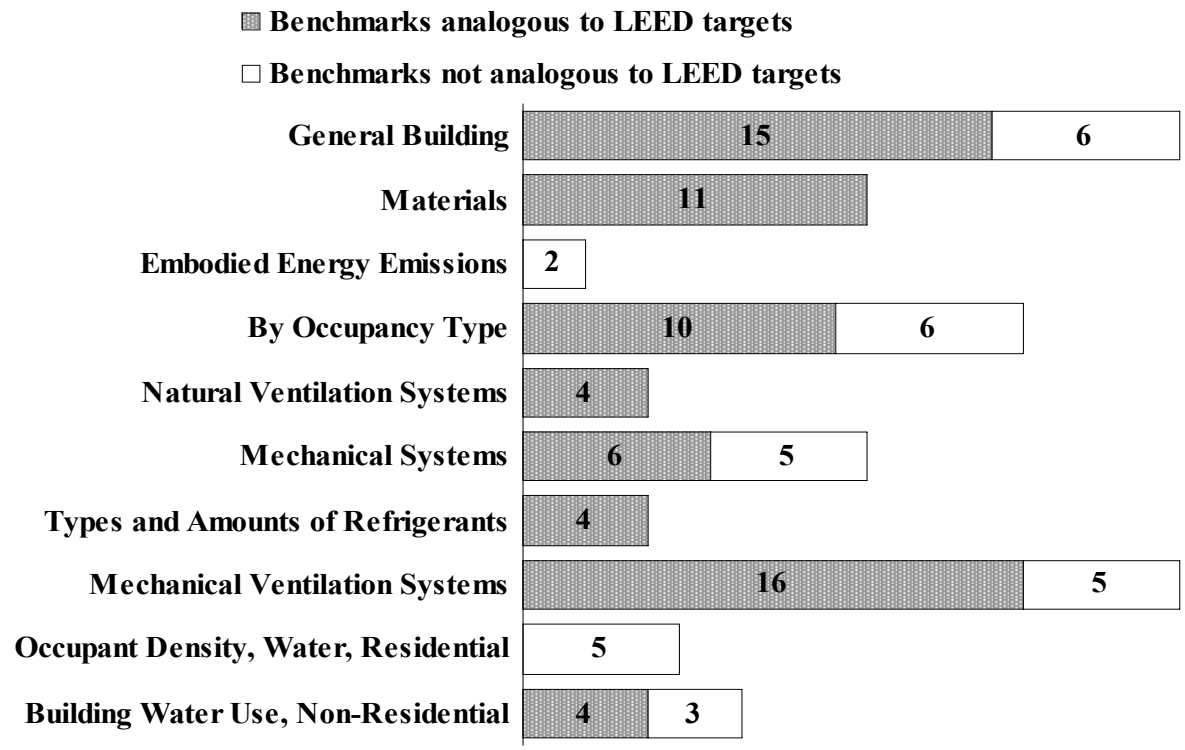

Figure 1 Number of GBTool benchmarks interpreted as *analogous* and *not analogous* to LEED targets (grouped by GBTool benchmark categories)

3.1.4 Level of Performance. LEED does not intend to describe performance at the minimum practice level. Nevertheless, a prerequisite itself might in fact be the "minimum acceptable practice" in some regions of the United States. Conversely, a credit constitutes a higher level of performance. As a result, LEED performance requirements that pertain to specific GBTool Benchmarks could perhaps be extrapolated to deduce a benchmark value. Since this is not an exact process, considerable judgment is required. However, using LEED for GBTool benchmarking might still be worthwhile. Codes and regulations dictating current practice do not cover all aspects of the GBTool benchmarks and a panel of regional experts may not be available. Therefore, LEED might be practical as a supplemental reference since it describes targeted performance levels and incorporates an extensive list of environmental standards.

3.1.5 Units. Both GBTool benchmarks and LEED targets have units of measure assigned to them. Only 5 of the 102 GBTool benchmarks use a similar description of performance and the same units as 4 of the 71 LEED targets. In terms of units, GBTool Benchmarks are difficult to extract from LEED targets, as in most cases they require different units.

4. DATA: FROM LEED DOCUMENTATION TO GBTOOL ASSESSMENT

The design team provides data for the following worksheets: Architectural Systems; Floor, Wall and Fenestration Areas; Technical Systems and Energy Consumption; Materials; Building Operations and Management; and Economics and Life Cycle Costing. Data from these worksheets and the regional information worksheets is fed into the Performance Assessment worksheet. The Performance Assessment is the comprehensive core of GBTool's project assessment relative to its regional context.

This part of the investigation explores how LEED data might assist a GBTool assessment. In order to be awarded a LEED certification, the project's general information and achievement

of targets needs to be documented following strict guidelines, including such items as narratives, calculations, drawings, specifications, reports, cut sheets, photographs, and an energy simulation. General project information and documentation of the *prerequisites* is the only source of LEED data consistently available for each project. Since *credits* pursued for a project are selected from all the rating system's credits, the extent of credit documentation varies from project to project.

4.1 Design Data

LEED is likely to provide useful data for GBTool design data worksheets by addressing a project's architectural characteristics, areas, envelope, technical systems (such as mechanical, electrical and plumbing systems), energy consumption, building materials, and hours of operation. However, LEED does not often take into consideration all aspects of a specific GBTool worksheet entry. An example of this is the LEED data for water use in a building, which only addresses plumbing fixtures and landscape irrigation. HVAC make-up water, drinking fountains, decorative water features, and exterior spigots are not considered in LEED's water use calculations. Furthermore, LEED commonly uses units of measure different from those required by GBTool, such as "cost" instead of "volume" of building materials. Therefore, collection of other data and conversion of units is necessary to complete data entry in GBTool.

4.2 Performance Assessment

As mentioned earlier**,** the Performance Assessment is the core of GBTool's project assessment in its regional context. The Performance Assessment is hierarchically organized in four levels: Issues, Categories, Criteria and Sub-Criteria, with 97 scored items distributed among the 7 Issues. Analyzing if and how many of the scored items relate to targets in the LEED rating system indicates whether GBTool worksheets feeding into the performance assessment could receive data input from LEED. Figure 2 shows approximately how many of the GBTool performance scores in the performance issues are *analogous* to LEED targets. The overall result is that 46 of the scores are *analogous* to 53 LEED targets. LEED data provided by documentation of targets could be complemented by LEED general project information, to supply data for GBTool.

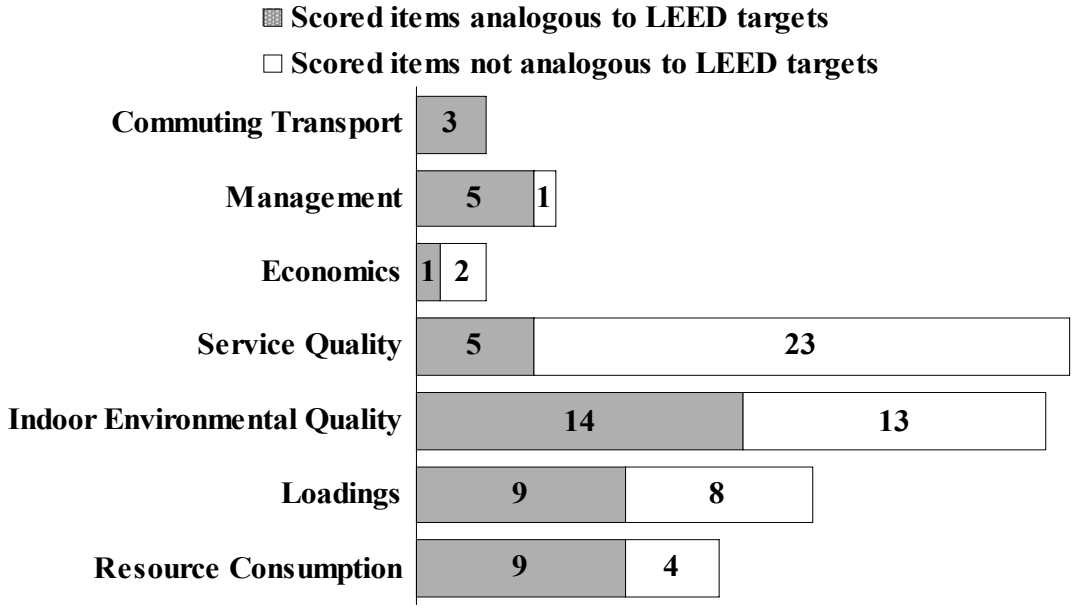

Figure 2 Number of scored items from GBTool Performance Assessment interpreted as *analogous* and *not analogous* to LEED targets (grouped by GBTool Issues)

4.3 Environmental Sustainability Indicators

Environmental Sustainability Indicators are absolute numbers, and thus can enable direct comparisons of the environmental impact of projects in different parts of the world. To determine the extent to which LEED data could contribute to GBTool Environmental Sustainability Indicators, this study analyzes these indicators for their correspondence to LEED data (Table 1). In summary, LEED can offer partial data for eight of the twelve indicators.

Table 1 GBTool Environmental Sustainability Indicators partially addressed in LEED

GBTool Environmental Sustainability Indicators		**Partially addressed in LEED data for targets and general project information**	
ESI-1	Total net consumption of primary embodied energy, GJ		
ESI-2	Net annualized consumption of primary embodied energy, MJ		
ESI-3	Net annual consumption of primary energy for building operations, MJ	**EA P1**	Minimum Energy Performance
		EA C1	Optimize Energy Performance
ESI-4	Net annual consumption of primary non-renewable energy for building operations, MJ	**EA C2**	Renewable Energy
ESI-5	Net annualized primary embodied energy and annual operating primary energy, MJ	**EA C1**	Optimize Energy Performance
ESI-6	Net area of land consumed for building and related works, m^2		General project information
ESI-7	Net annual consumption of potable water for building operations, m^3	**WE C1**	Water Efficient Landscaping
		WE C2	Innovative Wastewater Technologies
		WE C3	Water Use Reduction
ESI-8	Annual use of grey water and rainwater for building operations, m^3	**WE C1**	Water Efficient Landscaping
		WE C2	Innovative Wastewater Technologies
		WE C3	Water Use Reduction
ESI-9	Net annual GHG emissions from building operations, kg. CO_2 equivalent		
ESI-10	Predicted CFC-11 equivalent leakage per year in gm.	**EA P3**	CFC reduction in HVAC&R Equipment
		EA C4	Elimination of CFCs and Halons
ESI-11	Total weight of materials re-used in Design from on-site or off-site uses, kg.	**MR C1**	Building Reuse
		MR C3	Resource Reuse
ESI-12	Total weight of new materials used in Design from off-site uses, kg.		

5. CONCLUSION

The LEED rating system itself does not contribute much to regional customization of GBTool in the United States. Even though GBTool benchmarks and LEED targets (prerequisites/credits) show a significant overlap in subjects, in most cases they differ in units of measure. Also, LEED targets do not establish "minimum acceptable practice" levels, and they rarely address specific regional requirements. However, LEED targets and their underlying environmental standards might be useful as a secondary reference in the benchmarking process, where other sources do not provide adequate information.

Transfer of regional information from a rating system into GBTool could be easier if the rating system addressed "minimum acceptable practice" in regions defined by climate and regulations. Also, statistical information about which LEED targets are or are not pursued by projects could provide additional information for regional benchmarking in the United States.

Once a project is documented for LEED, there is much potential for using data from the LEED documentation for GBTool, even though the extent of the LEED data varies because pursued credits vary from project to project. Additional data collection and conversion of units of measure would generally be required. LEED data could provide substantial information for the GBTool design data worksheets, especially for the description of the technical aspects of the project. LEED data also could effectively address the Urban, Neighbourhood and Site Context worksheet. The match of LEED data and GBTool data becomes apparent in the GBTool Performance Assessment, where almost half of the scored items are *analogous* to LEED targets. For GBTool's absolute results, the Environmental Sustainability Indicators, LEED contributes partially to eight of the twelve indicators.

Further research into the correlation of LEED-generated data with GBTool data input, and the coordination of their units of measure, would ease the transfer of data from a LEED project into GBTool.

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Sustainable Working Place – concept/ model, case Aleksis Kiven katu 9

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1. INTRODUCTION

The Nordea Group is committed to the Declaration on Banking and the Environment, a Statement by the Banks on the Environment and Sustainable Development issued by UNEP, the environment organisation of the UN, in 1992. The Nordea Group does its environmental work within the framework of a confirmed environmental policy, annually updated environment programmes and environment work plans drafted for individual workplaces and business sites. In addition to the environmental impact of commercial activity in general, Nordea's own activities play an important environmental role. As a major real-estate owner and employer, the Group wants to develop its building stock in a direction that will decrease the load on the environment and improve the well-being of its employees. The aim of the *Aleksis Kiven katu 9* project was to develop an office building model for Nordea Pankki Suomi Oy that would fulfil the ever-growing demands of the future both ecologically and as a working environment. Premises that enable a top work performance also enhance the bank's profitability and employer image.

2. THE PROJECT ENVIRONMENT

Aleksis Kiven katu 9 is located at about five kilometres' distance from the Helsinki city centre. It is easily accessible by various means of transportation, including buses, trams and the metro, as well as commuter bicycle lanes. The building is in the Vallila district in an environment of some historical value. It closes the corner of Aleksis Kiven katu and Fleminginkatu, thereby completing the hitherto incomplete block. During the design phase, particular attention was paid to the materials, colouring, roof shapes and height dimensions of the surrounding buildings.

The building site had earlier served in various industrial uses. This historical heritage had left the soil widely contaminated, as studies carried out both before and during construction revealed. The polluted land (3,700 tons) was removed and transported to officially approved locations for reception and processing. Construction waste was recycled at a recycling rate of 85 %. The basement storeys of the building reach down 4 metres below the ground water surface. The ground water management relies on massive waterproof foundation walls cast in situ on the rock. The aim was to improve the environmental condition of the construction site without altering the ground water conditions unnecessarily.

The building has two storeys under ground and seven office floors above ground. The gross surface area is 14,334 m^2, the floor area of the office floors is 9,264 m^2 and the cubical content

50,620 m^3. The construction work began in March 2000 and the building was completed in July 2001. In November 2001, *Aleksis Kiven katu 9* won the Finnish environmental project competition in the field of real estate and construction. The jury evaluated the environmental aspects of the project on the basis of the Environmental Assessment and Classification System for Buildings developed in Finland. *Aleksis Kiven katu 9* scored high on all aspects, but the judges particularly praised the systematic work done on indoor air quality.

3. LIFE CYCLE EFFICIENCY

After the plans had been completed, an independent consultant carried out life cycle assessments of the energy use in the building. The assessments comprised the energy use in the building by a method of simulation and analyses of the use of displacement air in the garage, free refrigerating and solar shading. The life cycle assessments were also used to select the supplier of ventilation equipment from competing products. As part of the life cycle assessment, the indoor air conditions created in the office spaces were observed against the planned efficiency values of the HVAC plant as well as internal and external loadings.

Table 1 Aleksis Kiven katu 9, estimated annual energy use (with solutions according to plan).

Type of energy	Total consumption MWh/ a	Specific consumption kWh/a		Reference figure[1] kWh/a
		m^2	m^3	m^3
1. Heating	**944**		**18,7**	**31,7**
- Radiators	415		8,2	
- Ventilation	468		9,3	
- Warm service water	61		1,2	
2. Electricity	**780**	**62,8**	**15,4**	**28,2**
- Cooling	48	3,9		
- Fan	185	14,9		
- Lighting	379	30,5		
- Lifts	9	0,7		
- Others	159	12,8		

[1)] Average specific consumption according to the monitoring system of The Finnish Information Centre for Energy Efficiency and Renewable Energy Sources, Motiva Oy.

No exact age goals were set for the building or its parts. However, structural solutions that are known to be long-lasting were used in the frame, the elements, and the essential parts of the façades. The load-bearing structures consist of composite steel girders, low web girders and hollow-core slabs as secondary structures. A pillar grid (8 100 mm x 8 100 mm) provides

flexibility in the use of space. Towards the inner court yard, the outer walls are concrete sandwich structures; on the street side, the concrete internal skin has a mineral wool insulation built in situ. The thermal plaster façade meets the requirements of both the urban landscape and the authorities.

The service life of the principal components of the frame is over 100 years, that of the bearing parts of the external walls and the claddings about 50 years and the thermal plastering about 30 years. The office space windows are aluminium-clad wooden windows and the other windows are steel-framed and aluminium-lined window structures. The steel parts in the façades are hot galvanised and either painted or of acid-proof stainless steel. The roof is mainly spiral jointed, plastic-coated plate roofing and partly three-layer bitumen roofing made on the basis of the inverted roof.

The leading idea of the building design is flexibility in the structures, the space lay-out and the installations of house technology. The height, façade structures and heating, ventilation, air-conditioning and electricity technology of the ground floor allow its use as a commercial space as well. The office floors can be divided between two users per floor. The fixed staircases, technical rooms and sanitary rooms are located at the ends of the building wings, enabling flexible solutions of indoor decoration. Upper wall parts pre-built along the corridors make the placing of the light partition wall elements of the office spaces easy to change.

The structural flexibility was tested floor by floor during the application planning of the user's interior decoration needs. Additional electricity and data transfer network outlets and cables only needed to be installed in a few departments related to the company's dealing operations.

4. INDOOR AIR QUALITY IN THE BUILDING

In the building design, particular emphasis was laid on indoor air quality in the occupied floors and a healthy working environment. The work followed the principles of the Healthy House operation model coordinated by the Finnish Association of Building Owners and Construction Clients RAKLI and supported by the National Technology Agency Tekes. The planning work was supported by the experience gained from the bank's extensive programme of workplace humidity management. In order to ensure a pleasant and productive indoor climate, the Laboratory of Heating, Ventilation and Air-Conditioning of the Helsinki University of Technology acted as an expert of indoor air during the planning of the building and the supervision of its construction. The work of the laboratory included the following steps:

- **Checking the heating, ventilation and air-conditioning plans, work specifications and structural engineering plans from the point of view of the performance of moisture control techniques, building specifications and the choice of materials.**

- **Determining and monitoring the level requirements for the key factors of indoor climate and keeping the constructor informed of their status. Technical support for alternative solutions.**

  - *Surface materials*

  - *The effects of the furniture and fittings on indoor air*

  - *Instructions for cleaning and ventilating during work on the site*

- **Measures during the construction phase**

▪ *Technical support for scheduling, with special emphasis on ensuring the end result of the work on adjusting and balancing the air-conditioning*

▪ *Instructions for final cleaning and ventilation*

- **Measures during the reception phase**

  ▪ *Measuring the ventilation system hygiene*

  ▪ *Supervising the indoor climate checks*

  ▪ *Measuring the final ventilation*

- **Checking the texts on indoor air in the maintenance manual and suggesting appropriate improvements.**

- **Including the indoor air requirements in the maintenance agreements.**

- **Drawing up a plan on monitoring indoor climate and user satisfaction.**

During the project, the HVAC Laboratory went through technical and commercial documents, made calls, checks and measurements at the site and participated in site meetings in order to ensure that the work was carried out according to plans and set goals. The work laid particular emphasis on the following measures:

- **Checking critical material choices in the building (the use of Class M surface materials = the best class of classified products in terms of emission characteristics) with the purpose of preventing harmful emissions.**

- **Preparing the procurement of movable furniture and fittings with the purpose of preventing the impairment of indoor climate (panels, fabrics and lacquers used and the ventilation of the furniture and fittings in the target project).**

- **Suggesting measures to ensure the hygiene of the ventilation system.**

- **Assessing the noise caused by the ventilation system and the sound levels at the critical points (it is, for example, easy to lower the noise level of the cooling compressors and the cooling beams during the construction phase, but very difficult after the building has been completed).**

- **Suggesting ways of fulfilling the sound isolation requirements of the system walls.**

- **Suggesting ways of carrying out the gauging and adjustment of the ventilation system within the tight schedule without compromising the hygiene of the system.**

- **Gauging the hygiene of the ventilation system and follow-up gauging after cleaning.**

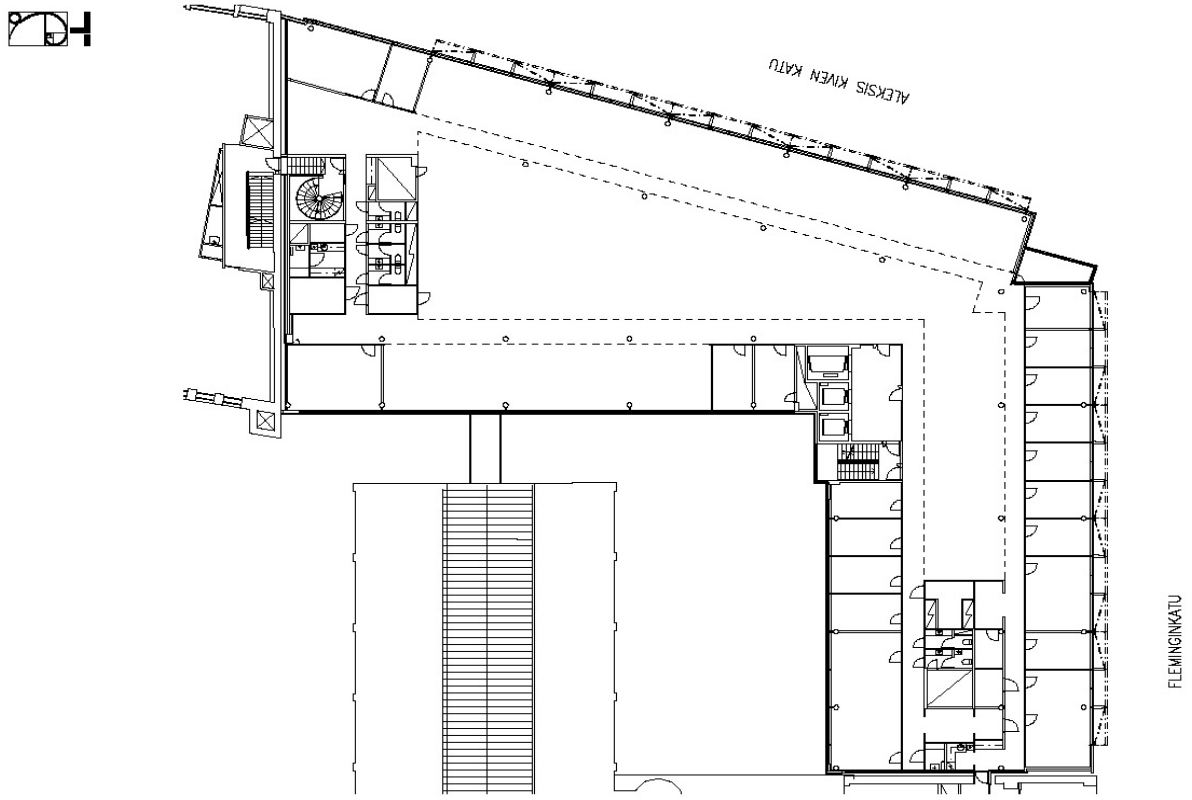
- **Gauging the temperature control and air escape of the rooms.**

- **Preparing the tender calls for property management and maintenance concerning indoor air.**

By continuously paying attention to the procedures of planning, procurements, construction, supervision and service and maintenance of the building in Aleksis Kiven katu 9, it was possible to fulfil the goals set for its indoor climate conditions so that Class S2 requirements of good indoor air quality (air renewal 2 l/s/m^2, air cooling and temperature control carried out for each room separately) were met.

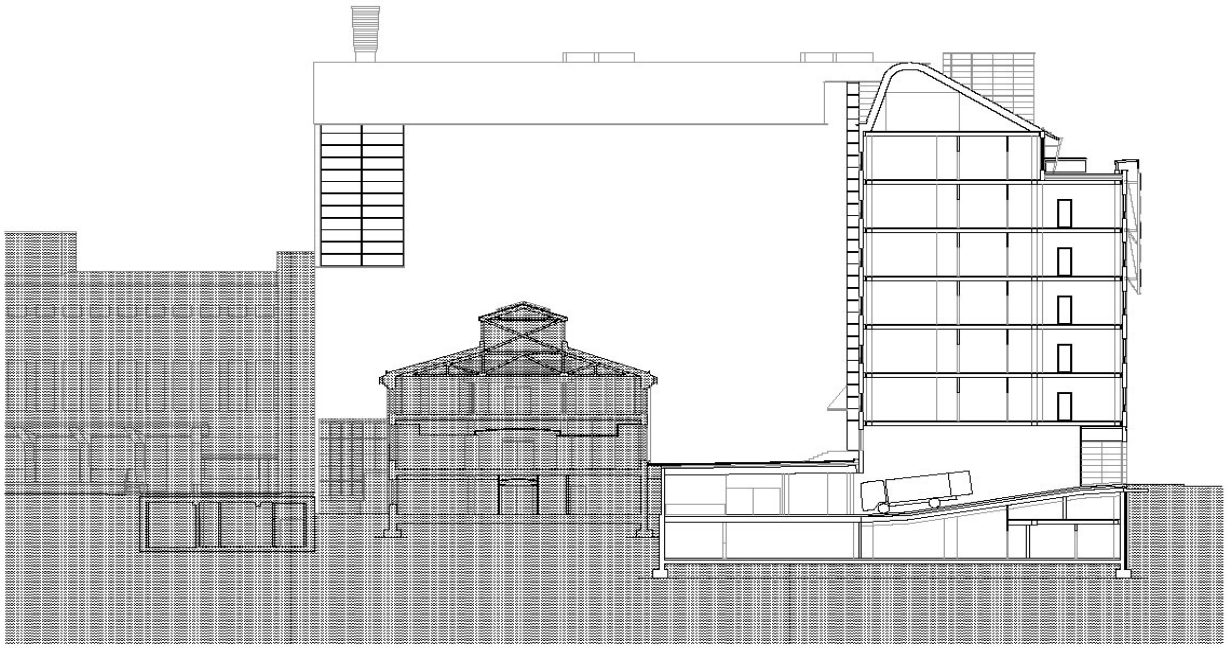
5. FINALLY

The best available professional expertise, a working method emphasising an efficient flow of information and a good end result, and a management method aiming at total success were applied during all the phases of the project. *Perhaps the most important of all the crucial elements was the successfully accomplished, top-quality and precise implementation of the total project process.*



Picture 1 Aleksis Kiven katu 9, floor plan.

Picture 2 Aleksis Kiven katu 9, plan cross-section.



Environmental Indicators for the Building Sector - User Questionnaires as a Basis for Indoor Indicators.

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1. INTRODUCTION

The Nordic countries have initiated a collaborative project, which aims to propose environmental indicators for buildings and property management. These indicators should be adapted for use in the environmental management of properties in general and specifically by companies certified according to ISO 14001 and EMAS. The indicators should be useful for management in the process of successively reducing a company's environmental impact. They should also be useful for communication with tenants and the market: that is, be easily understood by the public. The project will be finished in 2002.

So far, the proposal distinguishes between indicators on the company level and the building level. In both cases, the indicators are organised under the following headings: *Indoor environment, Resource use, Hazardous materials*, and *Waste.* Sweden was responsible for developing the indicators for the indoor environment, which is the focus for this paper.

2 INDOOR ENVIRONMENT

A high quality indoor environment is important for both health and comfort. We spend more than 90 % of our time indoors, in our homes and in our places of work—children and adolescents more than 95 %.

The relationship between indoor environment and health is complex, and the knowledge thereof is incomplete. Most health problems and symptoms of illnesses that can be caused by factors related to the building environment can also have other causes, such as, for instance, hereditary character, life-style, social situation, eating habits, or factors related to use of the building. Some causal relationships between the building environment and ill-health are, however, scientifically well-proven; for instance:

- Radon in indoor air can cause lung cancer (above all in relation to smoking);
- Radon in drinking-water can cause stomach and intestinal cancer;
- Damp and mould contaminated buildings can cause, Sick Building Syndrome (SBS)

- Legionella bacteria in tap water and air conditioning systems can disperse as aerosol in indoor air and cause legionnaire's disease;
- Noise can cause sleeping difficulties;
- Contaminated drinking water can give rise to stomach infections.

3 THE QUESTIONNAIRE AS MEASURING INSTRUMENT

Questionnaires are used in a number of different contexts. Many people, therefore, have experience of questionnaires, and general opinions about, for instance, content, the wording of questions, and the number of questions. If one makes the effort to answer a questionnaire, one expects that the results will be evaluated and considered in a serious way. In order to achieve representative results, the response rate of completed questionnaires is important (it ought to be over 75%). To not weary the tenants, questionnaires must be used sparsely, and the questions must be limited and exact.

Table 1. Some aspects to consider when using questionnaires

Advantages	**Disadvantages**	**Implementation**
Can access opinions and experiences	Weariness with questionnaires limits their usefulness	Limit the number of questions and pay careful attention to wording
Describes the degree of consensus of a population	Misunderstandings can be hard to trace	Explain who the research is being conducted for, and its practicalities
Provide information about unforeseen problems	One must be prepared to meet expectations	Explain the objectives, and the need for a high response rate
Only has minor interpretative problems	Sometimes difficult to separate causes to revealed problems	Allocate resources for implementation, analysis, and practical responses

4 EXISTING INDOOR ENVIRONMENT QUESTIONNAIRES

The table below shows a compilation of a number of existing questionnaires that deal with aspects of the indoor environment. These have been sorted according to the object of the questionnaire and the way it is normally used.

Table 2 Some existing questionnaires and their use

Questionnaire	**Type** [1]	**Description**	**Objective**
Örebroenkäten	R, O, S	H: Contains 11 questions with many subquestions. 4 pages. Questions about health are included.	Identify the building's influence on health
Stockholmsenkäten	R,	Contains 33 questions and sub-questions. 11 pages. Questions about health are included.	Identify the building's influence on health
EcoEffect	R,	Stockholmsenkäten with additions and deductions. 27 questions including background questions.	Identify the building's influence on health

[1] R=Residential buildings, O=Offices, S=Schools

Questionnaire	Type [1]	Description	Objective
Inneklima Spørreskjema, nordisk ventilationsgrupp	O	A large number of questions. Questions about health are included.	Identify the building's influence on health
NKI, Nöjd Kund Index, Svensk Hyresvärd Kvalitet AB	O	30-40 questions about facilities, security, services, housing area, etc. Contains some questions about the indoor environment.	Nöjd Kund Index (Customer Satisfaction Index)
Aktiv Bo	R	The same concept as NKI.	Nöjd Kund Index
Svensk miljöbesiktning	R	Contains 7 questions with subquestions. 2 pages. Questions about health are included.	Basis for survey

Table 2.

Questionnaire	Type [2]	Description	Objective
LKF, Lund Kommuns Fastighets AB	R	Contains 8 questions with subquestions. No questions about health.	Basis for survey
Miljöstatus för byggnader	R, O	Contains 8 questions (H). 1 page. No questions about health.	Basis for survey
P-märkning	R	17 questions. No questions about health. Similar to Örebroenkäten.	Basis for survey
Miljödiplomering, Göteborgs miljöförvaltning	R	5 questions with subquestions. No questions about health.	Basis for survey
Miljöenkät SABO	R	Contains, among others, 7 questions about the indoor environment. No questions about health.	Basis for environmental account

The use of questionnaires to collect tenants' opinions has been long used in Sweden, but to use them to establish an account of the indoor environment is relatively new. Up to now, the results of questionnaires has not been used to label the indoor environments of buildings.

Most commercial property owners have worked for many years with questionnaires to access information about their services: the so-called "Nöjd Kund Index" (Satisfied Customer Index). Some questions about the indoor environment are included, but above all, they are about things like facilities, security, services, and so on. This questionnaire is relatively extensive and demands a great deal of time both for the respondent and for the administrator. The commercial property owners who participate in NKI are officially ranked.

In Sweden, the property sector has developed a method called MIBB (Environmental survey of existing buildings) to survey indoor environments. The Swedish Federation for Rental Property Owners, The National Tenants' Association and major property owners support this method. The system demands questionnaire surveys to be undertaken regularly.

5 SUGGESTIONS FOR NORDIC "INDOOR ENVIRONMENT INDICATORS"

The aim of the suggested indoor indicators is to warn about faults and deficiencies in the indoor environment that can have a negative effect on people's health and well-being. Because

[2] R=Residential buildings, O=Offices, S=Schools

of the considerable experience of indoor environment questionnaires in Sweden, it was natural to propose a questionnaire as the basis for indoor environment indicators.

The connections between health, indoor environment, and the design of buildings are often complex. The effects of exposure to particular pollutants, which occur in low concentration, are practically unknown. Independently of the ways in which people are affected, their responses can provide conclusive information about the extent of the problem. Well-formulated questionnaires can, therefore, effectively describe how indoor environments are experienced. Many questionnaire answers from similar environments contribute to explanations of the causes of indoor environmental problems. Risks that cannot be experienced, for instance, high levels of radon, must be investigated through technical measurements.

In new buildings in particular, there is also a risk that processes are developing that, in the long run, could lead to indoor problems. For instance, a design that, in the long term, doesn't resist moisture penetrations may cause mould or chemical reactions the fabric of the building. Such reactions might also be caused by inappropriate combinations of material, or subsurface materials with the wrong pH (acidity) or RF (relative humidity). To be able to expose such risks, competent surveys need to complement questionnaires and measurements.

To find appropriate indicators, we first put together a number of possible measures, and associated health effects, environmental factors, environmental parameters, and measurement methods. After prioritising, we looked for an appropriate existing questionnaire to proceed from when creating a "Nordic questionnaire." We chose "The Stockholm questionnaire", which has been used in 10 000 dwellings in Stockholm and, thus has an extensive reference material. The proposed "Nordic questionnaire" has 12 questions about the indoor environment and 8 background questions, with versions for housing, schools, and offices. From the questionnaire, seven key questions were selected, and the responses from these questions were suggested as the key values, together with the three technical measurements (table 3).

Table 3 Suggestions for Nordic indoor environment indicators

Indicators based on questionnaire	**Measure**
Number of persons satisfied with their indoor environment	%
Number of persons not bothered by draught	%
Number of persons satisfied with the temperature during the winter	%
Number of persons satisfied with the temperature during the summer	%
Number of persons satisfied with the level of noise	%
Number of persons satisfied with the quality of the air	%
Number of persons satisfied with the amount of daylight	%
Indicators based on technical measurements	
Level of radon	Bq/m^3
Electromagnetic fields – electric fields	V/m
Electromagnetic fields – magnetic fields	µT

6 TEST OF THE SUGGESTED QUESTIONNAIRE

6.1 Housing

We have chosen to present the indicators from a housing questionnaire carried out in 3 buildings with a total of 60 flats. The average age of the tenants was higher than normal. The ques-

tionnaire was carried out in collaboration with the property-owner (a public housing corporation) and the local tenants' association. The response rate was 75%.

Table 4 Results from housing questionnaire

Indicator	**Percentage**	
Number of persons satisfied with their indoor environment	-	%
Number of persons not bothered by draught	39	%
Number of persons satisfied with the temperature during the winter	66	%
Number of persons satisfied with the temperature during the summer	88	%
Number of persons satisfied with the level of noise	92	%
Number of persons satisfied with the quality of the air	94	%
Number of persons satisfied with the amount of daylight	92	%

On the whole, the tenants were very satisfied with their housing environment. There was, however, certain dissatisfaction with draught, located to balcony doors and windows, and also with the spread of smells. There was no critique of the design of the questionnaire.

About one third of the questionnaire answers contained free comments, mostly concerning details such as the need to stop draughts, a disturbing smell, loud neighbours, poor lighting in the laundry-room, and so on; that is to say, things that in most cases can be addressed without any significant costs. It seems that the tenants avoided demanding costly measurements, perhaps because of the risk that these would lead to higher rents.

6.2 Schools

Ventilation is usually understood to be one of the more significant problems in school environments. Bad air is often a consequence of the fact that the premises are not used or maintained as they were intended. It is, for instance, usual that the air becomes bad when lessons are too long, or when too many persons are in a room. Other causes of the problem can be deficiencies in cleaning, smoking, contamination from materials and activities, and damp[3].

The school questionnaire was tested in a secondary school in Västerås that was built in 1965. There are currently 677 pupils and 103 full-time staff at the school. Only a small number of minor renovations have been carried out earlier. The school is now facing refurbishment, which comprises a complete renovation of 9746 m², between five buildings.

The school buildings have been subject to an environmental survey and the report from this survey exposes, among other things, faulty electrical installations, mould, insufficient heating and ventilation, an impaired façade, and poor windows. The ventilation had been checked and a radon survey was carried out in 1991, which showed results over 500 Bq/m². Radon suction was installed, and in 1992 the radon levels were measured again, revealing no problems. The occupants cannot themselves regulate heat or ventilation. There was suspected mould damage in rooms with water installations and the basement.[4] The time was now right to supplement these findings with a user questionnaire (table 5).

The questionnaire was carried out in collaboration with the property administrator and the school, in two classes with a total of 40 14-year-old pupils. The members of staff at the school

[3] Socialstyrelsens meddelandeblad 25/99
[4] Interview with the property administrator.

were positive about the questionnaire. An external person who also explained the object of the investigation distributed the questionnaire during lesson time.

Table 5 Results from the school questionnaire

Indicator	Percentage
Number of persons satisfied with their indoor environment	76 %
Number of persons not bothered by draught	33 %
Number of persons satisfied with the temperature during the winter	39 %
Number of persons satisfied with the temperature during the summer	90 %
Number of persons satisfied with the level of noise	43 %
Number of persons satisfied with the quality of the air	82 %
Number of persons satisfied with the amount of daylight	88 %

On the whole, the pupils were satisfied with the indoor environment, but there were also deficiencies. A large proportion of the pupils complained that it was cold in the classrooms and that draughts bothered them, above all from windows. Noise from the ventilation system and the surrounding also bothered a number of pupils. The pupils were positive towards the questionnaire, but thought that it was slightly boring and in some cases difficult to fill in.

6.3 Offices

There is a certain dread of questionnaires among commercial property management companies. Subsequently, they make certain demands of such surveys. It is not considered justified to carry out a questionnaire without any particular business objectives, or without it being directly related to making practical improvements. In buildings where it is difficult to find the causes of certain problems, a questionnaire can be a good aid.

The office questionnaire has been tested by a number of commercial property management companies. After a few adjustments were made, they considered it simple to use. The questionnaire has also been tested on 100 persons in three office buildings in Norway with the following result (table 6). The response rate was 50 %.

Table 6 Results from the office questionnaire used on 3 buildings

	Percentage		
Indicator	B1	B2	B3
Number of persons satisfied with their indoor environment	71 %	87 %	72 %
Number of persons not bothered by draught	88 %	87 %	82 %
Number of persons satisfied with the temperature during the winter	74 %	96 %	73 %
Number of persons satisfied with the temperature during the summer	-	-	59 %
Number of persons satisfied with the level of noise	45 %	96 %	90 %
Number of persons satisfied with the quality of the air	54 %	83 %	68 %
Number of persons satisfied with the amount of daylight	67 %	69 %	64 %

CONCLUSION

The use of environmental indicators aims to help property owners and tenants to make comparisons internally and externally. To use user questionnaires for indoor environmental indicators seems to be an effective way to meet this aim. The use of questionnaires gives surplus values because property owners get additional information about many other qualities and possible deficiencies in addition to information given by the indicator questions. They are also

given the opportunity to attend to deficiencies, and, through this, they can improve their relationships with their tenants. It is important to carefully plan the design of the questionnaire, the distribution and collection of them as well as surveys and physical measurements. Without a high response rate, the value of the questionnaire can be seriously compromised. It is also, therefore, important to use questionnaires sparsely and infrequently. Possibilities of combining or co-ordinating questionnaires should be investigated.

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Closing the Cycle of Building Materials —Recycling of Construction and Demolition Waste by Quality Improvement

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ABSTRACT
The production of construction and demolition waste (CDW) in the Netherlands is about 16 million tons per year. In order to protect soil and ground water, meanwhile, save the natural resources of raw materials, the Dutch government publishes a set of policy, such as Construction and Demolition Landfill Ban and Dutch Building Materials Decree. Nowadays, about 90% (by weight) of this kind of waste is being reused/recycled in the Netherlands. However, it is mostly reused as a road foundation material. The Dutch government aims at recycling CDW as secondary building materials at a higher technical level. The two main materials from CDW—concrete rubble and brick/masonry rubble—should be recycled in concrete industry and brick industry respectively. For this purpose, the quality should be improved in order to meet the requirements of quality standards from the aspects of intended applications as well as the requirements of environmental safety.

In this paper, the quality of CDW is analyzed according to aspects from both environment and applications, and the suitable mechanical and physical separation techniques are described. Based on the differences in physical behavior and chemical composition between concrete and brick, both dry and wet separation techniques are used. The laboratory study shows that concrete rubble and brick rubble can be separated from each other effectively by economic separation methods.

1. INTRODUCTION

By Dutch Ministry of Housing, Spatial Planning and the Environment, construction and demolition waste (CDW) is defined as waste released when buildings and other construction such as roads and bridges are built, renovated and demolished. Nowadays, the CDW is one of the largest solid waste streams in the Netherlands. The recycled aggregates from CDW are mainly used in road construction, sub-base, and embankments. From the point of view of "life cycle management", the treated products from waste should be reused or recycled for their original applications. Therefore, CDW is desired to be recycled in higher technical applications, for example, reused as concrete aggregates replacing natural aggregates.

In CDW, there are stony materials and non-stony materials. The stony materials, like concrete rubble and brick rubble, constitute the majority of CDW, about 90%. The non-stony materials consist of wood, paper, plastics, and metals. In addition, there are some harmful components for environment and people's health, like asbestos, tar, sulphate, and organics. According to the physical and chemical properties, only the stony materials can be reused as secondary building materials. From both aspects of environment and application, the quality of construction and demolition waste must be improved by removing contaminants. The contaminants are considered as the components that may negatively affect the reuse/recycling of materials or may be harmful for environment and public health. All contaminants can be removed by mechanical and physical separation methods.

In this laboratory study, two types of sample were used. One was the actual building waste obtained from a Dutch CDW processing company; another was the mixture of crushed brick and Portland cement mortar. The actual sample has been treated in the plant, and metals, wood, paper and plastics have been removed. This material contains concrete rubble, brick/masonry rubble, and a very small amount of sand lime brick, a few pieces of wood. By hand-sorting analysis, it is known that there are around 80% of concrete rubble and about 20% of brick rubble. This stony material can be used in road foundations. However, it can not be used as concrete aggregates or brick aggregates because of its lower technical quality. For the purpose to reuse it in higher technical applications, concrete rubble and brick rubble must be separated from each other so-that it meets technical standards. For the laboratory prepared material, it was obtained by mixing crushed clay brick with crushed mortar. Because the ratio of brick to mortar in this material is known exactly, it will be sure that a chosen technique is effective or not by checking the material recovery and purity after separation.

After separation processes, the concrete/mortar rubble and brick rubble will be obtained respectively, and these products can be reused as concrete aggregates and brick aggregates in stead of natural raw materials.

2. SUITABLE TECHNIQUES

For the sake of recycling concrete rubble and brick rubble respectively, the quality upgrading is an important step. The suitable separation techniques can be chosen based on the differences in physical or chemical behaviors between concrete/mortar and clay brick as shown in Table 1.

Table 1 Suitable separation techniques

Properties	**Brick**	**Concrete (or mortar)**	**Technique**
content of Fe_2O_3	3 to 4%	0 to 1%	magnetic separation
density	1.6–1.8 g/cm^3	2.3–2.5 g/cm^3 (or 2.0–2.2 g/cm^3)	Jigging/fluidized bed method
color	red or yellow	grey	color separation

2.1 Magnetic separation

In the mining industry, the magnetic technique is applied to obtain magnetic metals from non-magnetic metals. The content of Fe_2O_3 in brick is higher than that in concrete/mortar as shown in Table 1, as a result that brick is considered as a more magnetic material than concrete/mortar, the later can be considered as non- or weak magnetic material. Theoretically, concrete/mortar and brick can be separated from each other by a magnetic separator.

In this study, a Frantz Isodynamic separator was used to assess the magnetic properties of the laboratory prepared material.

The Frantz isodynamic magnetic separator is widely used for accurate dry separation on the basis of magnetic susceptibility of paramagnetic and diamagnetic particles between 10μm and 2.0mm, and can deal with up to a few hundred grams of material. The feed passes down a shallow vibrating chute between the pole pieces. Both the forward and side slope of the chute are adjustable. A partition at the end of the chute separates the particles more strongly affected by the magnetic force. The magnetic field is controlled by adjusting the d-c magnetic current and the machine angle. This separator can be controlled easily with low costs.

The separation of particles by a magnetic moment is generated by unit of volume of the material. If the chute is set at some angle α, the magnetic force F_m and the gravity F_g of the particle are at equilibrium: $F_m = F_g$, when the current I (A) is set in an suitable value to provide an suitable magnetic field as shown in Figure 1. Therefore, for a pure material, an average magnetic susceptibility can be found with the suitable current and angle to reach a balance point of magnetic force and gravity.

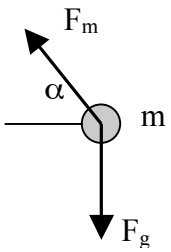


Figure 1 Forces on a magnetic particle

2.2 Jigging

The ratio of the apparent densities in water for concrete (or mortar) and brick is bigger than that in air (see Table 1). Therefore, the separation will be more effective in water. Jigging is such a suitable method. In a jig, the separation of materials with different specific densities is accomplished in a bed which is rendered fluid by a pulsating current of water (Figure 2).

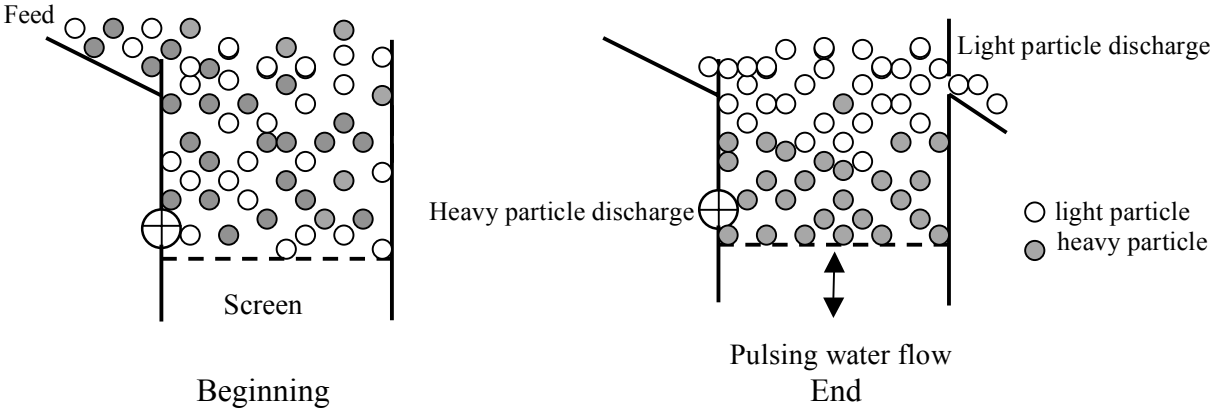


Figure 2 Sketch of a jig

When water is put under pressure by a plunger, the particles fall with different speeds to the bottom, depending on their densities. The heavy fraction will sink first and be discharged at the bottom of the apparatus. Jigging is generally used to concentrate relatively coarse materials down to 3mm. Jigging is a wet, inexpensive separation method, so the material is

washed when it is processed. In addition, it is easily controlled. However, the slurry that is left after separation has to be disposed.

2.3 Color separation

Color separation method is used to separate glass pieces in the mining industry. A 3D camera can easily recognize the differences among particles. Because there is a clear difference in the colors between concrete/mortar and brick, it is possible to apply color separation method to treat CDW. This process can only be effective when the feed contains less than ten percent of contamination. In a mixture of 50% to 50%, it will not be successful. The benefit of color separation is that it results in one extremely pure fraction and one mixed fraction. So it should be better to take it as the second or third step for treating CDW.

3. SEPARATION RESULTS

3.1 Magnetic separation

For the Frantz isodynamic magnetic separator, there are two parameters, the machine angle and current. First, pure brick and mortar samples were used to obtain the optimum operation parameters of the machine. The tests were done with red brick, yellow brick, hard-fired red brick, Portland cement mortar, and lime mortar. Because of the small size of the machine, only the fraction with a particle size between 0.15 to 2.36mm was used for tests. For each pure material, a median magnetic susceptibility is found at the point of a 50% magnetic fraction. The results show that at the same current, the amount of magnetic part decreases with raising angle; at the same angle, the amount of magnetic part decreases as current decreases. Figure 3 presents the results of red brick and yellow brick.

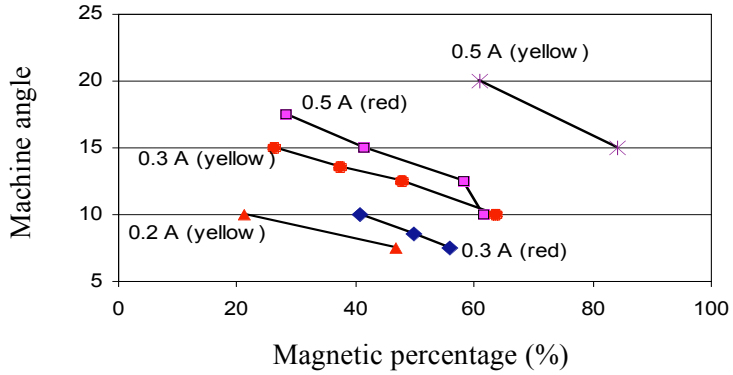
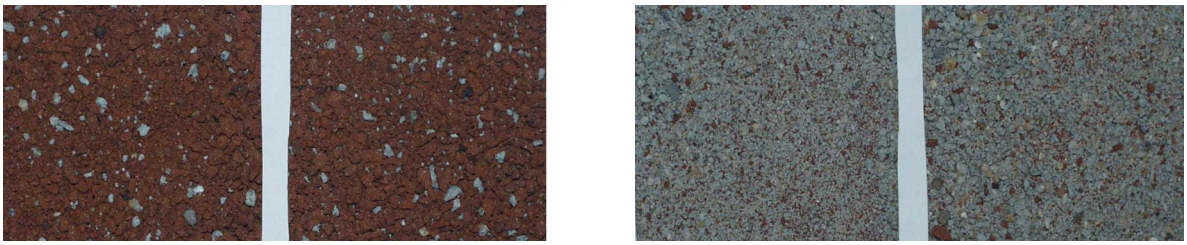


Figure 3 Magnetic percentage changes with machine angle

Then the mixed materials with the ratios of brick to mortar of 1:1, 3:7, and 7:3 were tested. The ideal result should be that the particles of brick end up in the magnetic fraction and the particles of mortar end up in the non-magnetic fraction. In order to achieve a satisfied result, this is meant the high purity and high recovery for both fractions of brick and mortar after processed, the optimum operation parameters were determined by tests. Table 2 gives the separation results. In Table 2, the purity was checked by visual examination of color. The word of “purest” means that all particles are in the same color, while “pure” means that there are a few pieces of other color particles. It is clear that a good separation can be obtained for the mixed materials. By Figure 4, it is known that the purity is high for both fractions of brick and concrete.

Table 2 Magnetic separation results with mixtures of brick and mortar

Sample	Percentage of brick (%)	Purity of brick	Purity of Mortar
hard red brick : mortar = 1 : 1	53.62	Pure	Purest
hard red brick : mortar = 3 : 7	33.37	Pure	Pure
hard red brick : mortar = 7 : 3	70.65	Purest	Purest
red brick : mortar = 1 : 1	56.62	Purest	Purest
red brick : mortar = 3 : 7	36.22	Pure	Purest
red brick : mortar = 7 : 3	70.6	Purest	Purest
yellow brick : mortar = 1 : 1	56.22	Pure	Purest
yellow brick : mortar = 3 : 7	40.50	Pure	Purest
yellow brick : mortar = 7: 3	72.83	Purest	Purest
red brick : lime mortar = 1 : 1	48.94	Purest	Purest
red brick : lime mortar = 3 : 7	29.71	Purest	Purest
red brick : lime mortar = 7 : 3	66.17	Purest	Purest



Prepared brick (93.2%) Separated brick Prepared mortar (87.2%) Separated mortar

Figure 4 The purity of separated brick fraction & mortar fraction

3.2 Jigging separation

The actual CDW sample was sieved into five fractions with different particle sizes: smaller than 2mm, 2 to 5mm, 5 to 10mm, 10 to 19mm, and >19mm. Each fraction excluding the finest was separated by a jig. Two concentrates for each fraction were obtained. One is on the top of the container and another on the bottom of the container. The upper concentrate is the brick fraction and the lower is the concrete fraction.



Brick fraction (89.0%) Concrete fraction (99.4%)

Figure 5 Separation by jigging (particle size > 19mm)

A good separation is easily obtained with coarse fractions. For the fraction with particle size larger than 19mm, both brick fraction and concrete fraction have got high purity (Figure 5). For the fraction with the smallest particle size (2 to 5mm), a good separation is obtained by an asymmetric stole at lower frequency. The results show that jigging is an effective wet method to separate light and heavy stony fractions from CDW, especially for coarse particles. After

jigging, the concrete fraction is cleaned enough and ready for recycling as concrete aggregates directly.

3.3 Color separation

Concrete rubble and brick rubble can be separated from each other by color because of the clear difference in colors between them. This can be done either by a computer connected with a 3D camera or by hand. A mixture was made with concrete rubble, red brick rubble, and yellow brick rubble, and then it was analyzed by a computer. The result is shown in Figure 6. It is clear that all particles are distinguished by their colors. This is an effective as well as expensive method. Colour separation with the help of a computer is relatively new. It has to be noted that this method is only effective after the CDW material has been washed.

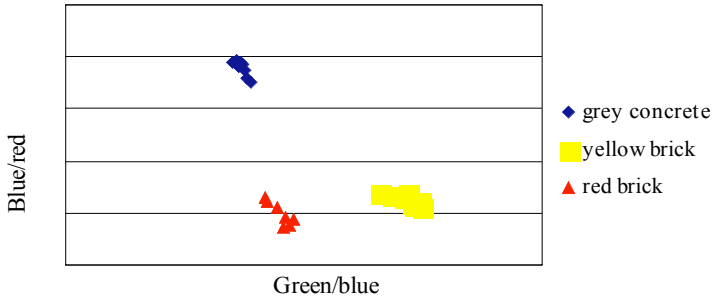


Figure 6 Color separation

4. CONCLUSION

- In order to recycle CDW as secondary building materials, the quality upgrading is an important step.
- By a Frantz isodynamic magnetic separator, both pure brick fraction and mortar fraction can be obtained with high recovery.
- Jigging is an effective wet method to treat CDW, especially for coarse fractions.

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Creating Publicly Available LCI Data Modules: An Up-Date of the US LCI Database Project

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1. INTRODUCTION

One of the most pressing dilemmas in life cycle analysis is the lack of common data that is transparent, collected in accordance with ISO standards, and publicly available at minimum cost to serve a wide variety of users and uses. It is impossible to objectively review and compare the environmental impacts of materials when analyses are based on different methods of data collection and use different sources for common processes like transportation fuel use and electricity generation. These difficulties can be largely overcome, however, and the way opened for more extensive use of LCA in building assessment tools and other applications, by making critically reviewed and accepted data publicly available.

This paper provides an up-date on a project to develop such a database in the United States — the US Life Cycle Inventory (LCI) Database Project. This database, being developed in accordance with ISO standards and provided at minimal cost in the form of LCI modules that can be linked, will create for the first time in North America a common foundation for all LCA work. It will provide those involved in labeling or the development of decision support tools with an essential resource and make it possible to objectively compare the environmental impacts of different materials and products.

Section 2 begins with a brief review of the project background and rationale. Section 3 then focuses on the completed first phase of the project. Subsequent sections build on that base, with emphasis on the data collection priorities and a brief discussion of how the LCI data modules can be used. The paper also notes concurrent efforts to coordinate through a SETAC/UNEP initiative with comparable work elsewhere in the world.

2. PROJECT BACKGROUND

The US LCI Database Project is a public/private research partnership to develop and make available LCI data for commonly used products and processes. The underlying intent is to facilitate the development of environmentally oriented decision support systems and tools; to provide regional benchmark data for generating or assessing company, plant or new technology data; and to provide a firm foundation for subsequent life cycle assessment tasks such as characterization, normalization and impact assessment.

The rationale for the project was clear to those of us who promoted it, and to those who provided financial and other support: life cycle assessment (LCA), an internationally accepted holistic approach for assessing the environmental performance of products, processes and services, hinges on the quality of the life cycle inventory, the quantification of material and

energy flows associated with a product or system under study. No matter how well a specific impact measure is crafted, nor how well a software tool is designed, the quality of results can never exceed the quality of the underlying LCI data.

Unfortunately, the application of LCA has been impeded by the time and money necessary to develop this kind of information, constraints that largely reflect lack of the peer-reviewed, comprehensive LCI data fundamental to reliable LCA work. Although there are a few LCI databases on the market, access to the information contained in them is generally restricted, protected by copyright agreements, or otherwise not verifiable. In some cases, manufacturers are reluctant to release studies for a variety of understandable reasons generally related to their commercial interests. In other cases, consultants that have developed databases are reluctant to reveal too much detail in order to protect their own commercial interests or the interests of the proprietary sources from which information was obtained. Whatever the reasons, perpetuation of this situation is inconsistent with the free, transparent, and open exchange of information required for reliable and verifiable technical and scientific investigations and/or assessments of products. National LCI databases, maintained by reputable agencies or institutions and available to all, offer a clear route around these barriers.

Environmental issues are constantly in the public eye, whether to do with global climate change, toxic emissions, hazardous wastes, or other concerns. Clearly, the public's collective concern surrounding these and other issues is driving much of today's interest in sustainable development, industrial ecology, and design for the environment. In response, organizations such as the World Business Council for Sustainable Development are busily establishing standards for metrics to characterize the eco-efficiency of industries and products. And those metrics, which will ultimately be used to characterize the 'Sustainable World' and define sustainable product systems must in part be comprised of life cycle metrics. The creation of national LCI databases is again supportive of these efforts.

2.1 Phasing

The project was conceived as a three-phase effort, with each of the phases defined as follows:

Phase I, an intensive initiation and planning phase;

Phase II , basic data collection, analysis and review; and

Phase III , long-term data dissemination, database expansion, and maintenance.

Phase I of the project began on May 1, 2001 with funding from the US Department of Energy, the General Services Administration, and the US Naval Facilities Engineering Command through the National Renewable Energy Laboratory (NREL). The first phase was undertaken by the Canadian ATHENA™ Sustainable Materials Institute in association with two US consulting firms, Franklin Associates Limited and Sylvatica. The project quickly gained national prominence as a result of a Meeting of Interests hosted by Ford Motor Company at its Dearborn research center on May 21, 2001. During that meeting, the funding agencies, the Environmental Protection Agency, Ford and other participants representing the industrial, academic and consulting communities voiced strong support for the project. Phase II of the project is now underway with a combination of public and private sector funding.

3. SUMMARY OF PHASE I

The objective of Phase I was to develop a research protocol and establish research parameters including products, processes, data categories and data quality. An advisory group was formed

with 45 representatives of manufacturing, data user, government and non-government organization interests, as well as LCA experts. Following a workshop held on July 24, 2001 in Washington, D.C., a basic Phase I work program was put in place. Central to that plan was the formation of five working groups, which focused on specific issues and database requirements, with the consulting team responsible for the basic production of materials.

The five work groups dealt with the following tasks:

1. assimilation of work group outputs and material from other sources to create a draft research protocol;
2. data quality, uncertainty and variability as well as the definition of basic transformation processes;
3. transparency, data access and data format issues;
4. definition of substances (elementary flows) to be tracked and the assessment of existing database availability; and
5. development of common energy combustion and pre-combustion databases, including electricity generation and transportation, as well as identification of the products or materials to be studied and definition of the appropriate 'gates'.

3.1 Project Goal and Scope

In LCA parlance, Phase I was the goal and scope definition step. The workshop participants agreed that the goal of the project was not to carry out full product LCIs, but rather to make the creation of such LCIs easier while reducing the level of data inconsistency and incompatibility that currently plagues the LCA field in general. The therefore differs from typical life cycle assessments of individual products, processes or systems, and we especially had to anticipate a much broader range of potential uses and users of the LCI data.

It was also generally agreed that the data would be developed and made available as a set of modules that quantify the environmental burdens of common unit processes encountered during product manufacture, use, and disposal. Since the intent was to make it possible for users to readily access, combine and augment the modules to develop more complex LCIs or full LCAs, we had to carefully distinguish the concept of publicly available data from the idea of data for use by the public. We expect users of the database will include the following groups:

- manufacturers, researchers, policy analysts, and others undertaking LCAs of specific products or processes;
- developers and users of tools for LCA practitioners;
- developers of tools for non-practitioners which typically do not allow the user to modify embedded databases; and
- organizations or individuals engaged in product assessment and labeling at various levels of system complexity from relatively simple consumer products to complex systems like buildings and automobiles.

The common thread running through this list is an assumed level of knowledge and sophistication on the part of the anticipated users. Nevertheless, we did not know in advance (nor do we yet know) precisely how or why individual database modules would be used. We therefore had to develop the research protocol on the assumption that potential uses of the data would dictate the most stringent requirements in terms of data categories, transparency, review and other factors that are normally determined by the starting goal and scope statement of a

study. In general, that meant assuming the data will be used in full LCAs for the purpose of making public comparative assertions.

From a scoping perspective, it was decided that individual data modules should be developed in Phase II for:

- common energy combustion and pre-combustion processes, including transportation and electricity generation;
- basic cradle-to-gate manufacturing processes for a wide range of commonly used materials and intermediate products;
- transformations (stamping, molding, etc.) and finishing operations (painting, welding, etc.); and
- end-of-life processes such as composting, baling, incineration, etc.

Notwithstanding the basic goal and scope, we recognized that some modules might in fact provide cradle-to-gate LCI data for specific products simply because such product-specific data is an essential building block (e.g. the production of transportation fuels) or because product-specific data reflects the only practical level of presentation (e.g. the production of green softwood lumber). The key point is that, even in such cases, the individual modules will not cover the entire life cycle, and very critical aspects of functionality, maintenance, disposal or other LCI elements may be excluded. The project is providing an LCI data resource, not complete product LCIs. Very clear and explicit cautionary notes must therefore be attached to all of the data developed and made available through this project.

During Phase I, NREL committed to serve as the data repository and access agency, and to take responsibility for Phase III, long term database maintenance, updating, and expansion — a critical set of functions if the project is to have lasting value. NREL also established a project web site <http://www.nrel.gov/lci/> to ensure transparency form the outset and encourage participation from any interested parties. All key working documents, the research protocol and the final Phase I report have been posted to that site, which also has provision for receiving comments on specific documents or the process in general.

4. RESEARCH PRIORITIES

During Phase I we established the following broad categories to set the first order research priorities.

1. Fuels, Energy, and Transportation
2. Products and Materials
    a. Building and Construction
    b. Automotive and Durable Goods
    c. Commodity Chemicals and Materials
    d. Packaging
3. Transformation Processes
4. End of Life (Recycling, Landfill, etc.)

Since each of these priority groupings covers a large number of separate unit processes, only the highest priorities are initially being studied in Phase II. Additional unit processes will be added as resource permit. In the meantime, however, data modules will be made available as they are developed, peer reviewed and accepted for dissemination. The fuels, energy and transportation category is the highest priority area because all LCAs draw on that kind of data,

and it is variability in the treatment of these common processes that often leads to a lack of comparability between studies.

Within the sub-groups of the products and materials category, we first set high, medium, and low priorities, and then refined the lists on the basis of a preliminary data availability survey. In the case of the transformation and end of life categories we identified an even small number of high priority processes, and will probably further refine that list as well.

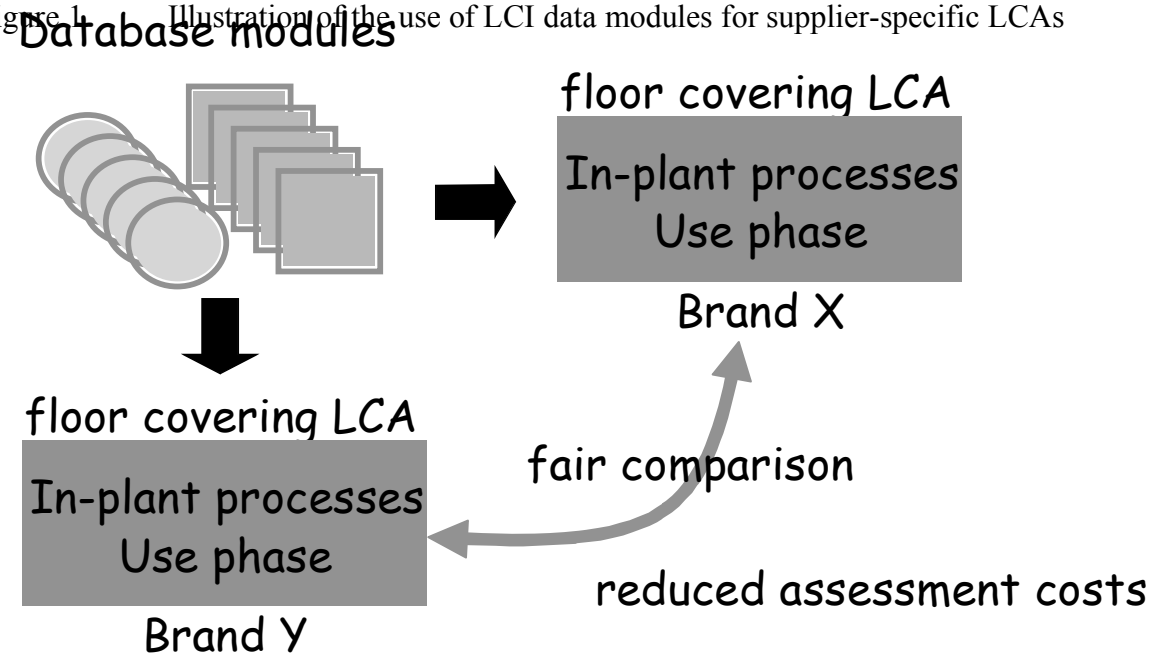
The key point is that this is the beginning of an ongoing process, not a one-time study that will yield a pre-defined set of LCI data. In the two-year Phase II program we intend to develop as many of the most useful data modules as possible given the time and resources. Although only a portion of the estimated $1.2 to $1.8 million funding requirement has been met, the work has nevertheless started.

5. THE USE OF DATA MODULES

As noted earlier, the project will focus on data modules that can be combined and used in more complete LCAs. For example, data modules for electricity generation will cover the mix of energy forms used in a defined grid, efficiency factors, line losses and generating plant effects. But the pre-combustion effects associated with the energy forms will be provided in separate modules. Similarly, the LCI for a specific product need only specify the amount of transportation required in ton/miles by mode. Common modules will then provide the basic energy use factors and direct combustion emissions with other modules providing the pre-combustion effects as in the electricity generation case. Other modules will provide data on generic production effects for a range of commonly used input materials and processes. For example, there will be modules dealing with basic steel and aluminum production, lumber and board products, a range of petrochemical feedstocks, and so on, all reflecting average or typical production practices.

As illustrated in Figure 1, below, the use of common data modules will allow those doing LCAs of specific products to focus on the elements that are unique to the specific plant or process.

Figure 1. Illustration of the use of LCI data modules for supplier-specific LCAs



The example in the above illustration is for two floor covering manufacturers that add their own in-plant, or even use-phase, data to the common elements, like transportation or basic petrochemical production. The result is a much fairer comparison at greatly reduced costs for each manufacturer. The costs will be especially affected by the fact that suppliers will no longer have to trace all of the important process inputs back through the entire supply chain.

Because the modules will typically be used in combination with each other, and with other data to be developed or provided by data users, we continue to emphasize the earlier point that the data is for use by those who are reasonable knowledgeable about LCA. Even then we have to ensure users are provided with a comprehensive guide to forestall misuse and prevent, to the extent possible, double counting or other errors that could occur when aggregating data or combining data from different modules.

6. SETAC/UNEP LIFE CYCLE INITIATIVE

The US LCI Database Project is one among several such projects underway or contemplated in various parts of the world. Given the fact that many essential inputs to production processes are internationally traded, and in some cases may not be produced at all in the United States, it is critical that there be an ability to share this kind of data across internationally. That ability, in turn, requires care to ensure reasonably consistent protocols and treatment of common elements. We are therefore very supportive of the SETAC/ENEP Life Cycle Initiative launched earlier this year. In addition to providing a link between projects in various countries, the Initiative can provide a much-needed forum for comparing and reconciling LCI research protocols. Indeed, it may eventually lead to the development of common databases for certain highly traded commodities, especially those produced in less developed parts of the world where LCA may still a relatively low priority.

7. CONCLUDING COMMENTS

The validity and value of all environmental assessment tools, whether focused on individual products and materials or complex systems like buildings and automobiles, and no matter how sophisticated, depends on the quality of the basic LCI data on which they are based. If tools purport to help people make decisions among competing products or among alternative designs where there are differences in the materials used, it is essential that the underlying LCI data for individual products be developed on a consistent, comparable basis. The quality of LCI data is equally critical to all methods for characterizing environmental effects and for calculating impacts, scores or other measures.

Right now, there are no US LCI databases that can be readily accessed and that meet basic criteria for consistency, comparability and transparency. There are some databases that a practitioner might use (although the list of products and materials covered is certainly not comprehensive in the context of US industrial activity), but — and this is fundamental — they are not developed to a consistent standard. There is no guarantee of a level playing field when comparing one product to another. Nor can a practitioner or the developer of a decision support tool easily combine data from the different sources without fear of violating important LCA principles.

The US database project is a critical step toward resolving these kinds of problems and fulfilling the promise of LCA. With this project, and others like it, we can visualize a future in which basic LCI data is available and flows with internationally traded products, thus

overcoming yet another serious impediment to the proper application of life cycle assessment techniques.

Integrating LCA Tools in Green Building Rating Systems

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1. INTRODUCTION

Green building rating and certification systems are intended to foster more sustainable building design, construction and operations by promoting and making possible a better integration of environmental concerns with cost and other traditional decision criteria. Different building assessment systems approach this task from somewhat different perspectives, but they have certain elements in common. Most, if not all, deal in one way or another with site selection criteria, the efficient use of energy and water resources during building operations, waste management during construction and operations, indoor environmental quality, demands for transportation services, and the selection of environmentally preferable materials. And they do an admirable job of fostering and facilitating integrated design practices and a holistic approach. In short, the systems generally capture the complicated, web-like relationship between a building's construction and operations and its impacts on human health and the environment, a relationship that is similar to the complexity of ecological systems in nature where nothing functions or changes without resonating in another part of the system.

But there tends to be a disconnect between broad understanding of this relationship and the specifics intended to foster appropriate decisions. In a sense, there is an absence of a clear objective function, or at least a failure to always have the objective function in the forefront. The ultimate objective from an environmental perspective is to minimize the flows from and to nature: the use of natural resources of all kinds and emissions to air, land and water throughout a building's complete life cycle. Until we know much more at a hard scientific level, it is difficult to conceive any more sensible route to environmental sustainability.

The failure to maintain a clear objective function in building assessment systems is most notable in the case of material selection criteria and, to a lesser extent, in the energy use criteria. In fact, defining "sustainable materials" and encouraging their use seems to be one of the biggest challenges for the developers of green building rating systems. We believe that challenge must ultimately be met by a better integration of life cycle assessment (LCA) techniques and LCA-based decision support tools in whole building rating and certification systems.

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[1] ATHENA™ is a registered trademark of the ATHENA™ Sustainable Materials Institute. For the sake of simplicity, the trademark designation is not used throughout this document, but it is assumed to apply wherever the name ATHENA is used.

This paper focuses on how we might accomplish that end. It includes a more detailed examination of the problem with reference to the different approaches of GBTool and LEED™[2], which tend to define the ends of the spectrum of possible approaches, a discussion of the role for LCA and ways to accomplish the integration, and a brief discussion of key constraints that must still be addressed and overcome.

2. THE PROBLEM

The problem is most easily understood in the context of the credits or scores assigned in rating systems for building material choices. It arises because material credits have typically evolved from a consensus-based understanding of environmental issues, understandings that, in some cases, have taken on an aura of conventional environmental wisdom that does not always stand up to objective analysis. As well, there is a risk of confusing means and ends, with the means becoming objectives in their own right to the possible detriment of environmental performance.

A couple of examples from LEED make the problem clear. LEED offers substantial credit for the use of recycled materials, the presumption being that recycled materials will automatically result in reduced environmental burdens. However, this may not always be the case, and recycling in any given situation may be good or bad. For example, recycling can save landfill space, but the process of recycling a given product may take more energy and adversely affect air quality more profoundly than would production from virgin resources. The focus on recycling ignores this possibility and implicitly gives more weight to solid waste and resource depletion issues than to global warming or other measures. The point is not that one issue or indicator is more important than the other, but that commonly held beliefs or assumptions appear to take precedence over data and facts in the decision process. In fact, recycling is probably the best example of a confusion of ends with means. Recycling has always been only a means to the objective of reduced flows from and to nature, but over time it has taken on the mantle of an objective in its own right.

A somewhat more subtle example is the LEED credit for the use of rapidly renewable materials. The stated intent of that credit is to, "reduce the use and depletion of finite raw, and long cycle renewable materials by replacing them with rapidly renewable materials." Rapidly renewable is defined as a rotation period of less than 10 years. Among a number of problems with a credit like this, is the fact that it ignores the value of land as a finite resource as well as the implications of all of the fertilizers, pesticides, insecticides, etc., that may be used in the process of producing rapidly renewable materials. Nor is there any a priori scientific reason for preferring a short cycle renewable over a long cycle renewable, let alone an arbitrary 10 year rotation over a 12, 15 or 20 year rotation.

Similar kinds of problems arise even with the most sacred of rating system credits, those for operating energy use. Not all energy is equal: combustion emissions differ by energy form, and the upstream, pre-combustion implications of producing and moving different energy forms can be even more significant. As a result, a credit system that promotes minimal energy use without regard for the form of that energy may be misleading, especially if it

[2] LEED™ is a registered trademark of the US Green Building Council. LEED stands for Leadership in Energy and Environmental Design. For the sake of simplicity, the trademark designation is not used throughout this paper but it is assumed to apply wherever the acronym LEED is used.

results in the use of materials or construction techniques that have significant resource use or emission implications in their own right.

An argument often advanced to support giving precedence to the minimization of operating energy irrespective of material use implications is that operating energy use dominates the total of operating plus embodied energy. While this is generally true, the argument ignores other potentially serious environmental implications of too narrow a focus on operating energy. For example, toxic releases to water are more likely to result from the production of building materials than from building operations, and we must therefore cast our net wide enough to catch a full range of potential effects.

These are complex issues, and there is a danger in over-simplifying in a short conference paper. One of the complications worth noting here, for instance, is the potential for conflict between stewardship reasons for a specific credit and the realities of specific industries. For example, the recycling credit is relatively easy to achieve by the use of steel construction systems and might therefore promote more use of that material. But it is unlikely to promote more recycling because recycling is already a fundamental part of that industry's structure and operations, and is driven primarily by industry economics.

Before leaving this section, we must point out that the LEED Materials and Resources Technical Advisory Group (TAG) has already identified problems of the kind discussed here, and has wrestled with how they might be resolved in future versions of the system.

3. THE USE OF LIFE CYCLE ASSESSMENT METHODS

The LEED TAG has considered various methods to add importance and weight to matters such as durability, expected life of a building, reusability, and so forth. One recommendation has been to develop a matrix that would integrate such objectives with the amount of product or material in a building, with a variable outcome based on project inputs. The TAG has also discussed the potential role for LCA, which would be roughly approximated by the matrix approach. LCA is also the direction that has already been at least partially adopted in GBTool.

3.1 LCA Defined

LCA is a methodology for assessing the environmental performance of a service, process, or product, including a building, over its entire life cycle. Although the technique is still maturing, especially the aspects dealing with ultimate impacts on human and ecosystem health, it has become the recognized international approach to assessing the comparative environmental merits of products or processes. We cannot go into the details of LCA here, but the basic methodology for the various steps in the methodology — goal and scope definition, inventory analysis, impact assessment, and interpretation — is set out in the ISO 14000 series of standards. The steps of most concern here are the life cycle inventory analysis (LCI) and the initial stages of impact assessment.

An LCI involves detailed tracking of all of the flows in and out of the system of interest — raw resources or materials, energy by type, water, and emissions to air, water and land by specific substance. This kind of analysis can be extremely complex and may involve dozens of individual unit processes in a supply chain (e.g., the extraction of raw resources, various primary and secondary production processes, transportation, etc.) as well as hundreds of tracked substances.

The LCI data can then be characterized in terms of impact potentials (e.g., for global warming, ozone depletion, etc.) and included in a series of measures called mid-point indicators. While the indicators do not answer the question of ultimate environmental impacts, they do provide a convenient way to summarize and compare the masses of inventory data, and at least make decisions on the basis of whether an alternative is likely to result in a reduction of flows from and to nature. The jury is still out on the best means of bringing mid-point indicators together in an assessment of ultimate, or end-point, impacts.

3.2 LCA-Based Decision Support Tools

There are already several LCA-based building-oriented decision support tools in use or under development in various parts of the world, for example Envest in the UK, EcoQuantum in the Netherlands, and ATHENA in North America. Although they use different modeling approaches and are regionally-specific, all of these tools work at the level of whole buildings and use embedded LCI data to develop mid-point indicators of the environmental implications of design alternatives. Table 1 shows an example of the summary output from ATHENA for a recent study of an 18 storey office tower, with five levels of underground parking, designed using a conventional reinforced concrete structure with a curtain wall exterior cladding system.

Table 1 Summary of total life cycle embodied effects by major building component from office building LCA using ATHENA.

Building Components	Embodied Energy (Gj)	Solid Wastes (tonnes)	Air Pollution (index)	Water Pollution (index)	GWP (Equivalent CO_2tonnes)	Weighted Resource Use (tonnes)
Structure	52,432	3,273	859.0	147.0	13,701	34,098
Cladding	17,187	281	649.8	24.7	5,727	2,195
Roofing	3,435	145	64.8	5.8	701	1,408
Total	73,054	3,554	1,573.6	177.5	20,129	37,701
Per m^2	2.36	0.11	.05	.006	.65	1.21

Notes: The air and water pollution indices are based on the critical volume measure (method). GWP is global warming potential. Energy and emission estimates do not include operating energy.

The results in Table 1 are for the complete building life cycle including maintenance and replacement of materials, demolition, and transport to land fill of materials not likely to be reused or recycled. However, as indicated in the table notes, the results exclude operating energy and cover only the embodied effects. They nevertheless provide a good picture of a full range of environmental effects that result from the specific design and material choices made for the building under study. Those effects could readily be compared to alternative designs to select the one that provides the best performance, with best determined by an implicit or explicit weighting of the issues. We should note that the inventory results contained in the model would allow the calculation of other measures such as ozone depletion or acidification.

The key point with regard to this kind of analysis is that it encompasses a full range of estimated effects and goes beyond proxy measures like recycled content, or narrowly focused preferences like the preference for short- versus long-rotation renewables. For example, the estimates take account of recycled content in accordance with the ISO standards for various recycling situations, but they do so with full regard for the effects of the recycling process itself, including any related transportation.

Even if this approach does not cover all of the issues of concern in a building assessment, it establishes a much better basis for informed environmental choices and therefore for assessing the relative merits of a building from a materials use perspective. It is also important to note that, because this kind of assessment is at a whole building level, it takes into account the relationships inherent in a building system where the choice of one material for an application may dictate the use of other materials for thermal or other reasons.

3.3 The Use of LCA in Existing Assessment Systems

We have already noted the absence of LCA data in the LEED assessment system and the problems that can arise as a consequence. We should also look at GBTool, a more experimental system at the other end of the spectrum, where substantial advances have been made toward integrating LCA results.

GBTool accepts input data for a very broad range of materials as part of its basic structure. That data can be used in a tool like ATHENA to generate embodied energy and emission results of the kind shown in the previous sub-section. Those results are then returned to GBTool to generate a score that relates directly to material choices. This process has been followed by the Canadian Green Building Challenge team since the first round in 1998. GBTool also contains a relatively crude calculator for embodied effects, which draws on the same input data and is for use by those without access to ATHENA or an equivalent tool. The difficulty with that approach is the regional sensitivity of LCI data and the importance of undertaking such studies in a regional context.

Nevertheless, the crude calculator approach at least serves an educational purpose by giving users some insight into the environmental implications of their material choices. Other assessment systems like the Minnesota Design and the Canadian BREEAM Green Leaf system also offer 'educational' credits for the use of ATHENA or an equivalent, an approach considered by the LEED materials committee for the next version of that system.

4. CONSTRAINTS

There are some key constraints to be overcome before LCA-based tools can be fully integrated in building assessment systems. Two, in particular, deserve emphasis: the problem of data availability, and the absence of appropriate references or benchmarks against which to judge LCA results for a particular building.

4.1 LCI Data Availability

LCI data is expensive and difficult to obtain, and is most often kept confidential by those manufacturers that do undertake studies. As well there is a problem of ensuring comparable data for different products or materials if the data is not generated by one organization, or at least by the use of a common protocol. However, this constraint is gradually being resolved through the creation of publicly available LCI database in various countries.

In North America, for example, the U.S. LCI Database Project is a public/private research partnership dedicated to the creation of a publicly available LCI database of commonly used materials and processes. Manufacturers, researchers and the developers of tools or assessment systems will be able to call on the database to develop complete LCAs for specific processes, with reasonable assurance that the fundamental LCI data is sound and without having to redo LCI studies for common elements like energy production and basic transportation.

The ATHENA Institute undertook the first phase of the project in association with Franklin Associates, Ltd., and Sylvatica, with funding from several federal governments departments through the National Renewable Energy Laboratory (NREL). The data collection phase is now underway, and NREL has taken on the responsibility for long term dissemination, expansion and maintenance of the database.

An international project, the SETAC/UNEP initiative, will be concurrently addressing issues related to data availability and comparability across international borders. As well, governments and research organizations in various countries are continuing to develop characterization and other impact assessment methods.

4.2 Judging significance

The development of appropriate references or benchmarks to judge the significance of LCA results is not so easily resolved. When a tool like ATHENA is used to provide LCA input to GBTool, the requisite reference cases have to be constructed and separately assessed for each building, a time consuming and expensive process. That has proved feasible within the context of the Green Challenge Process but probably would be unacceptable for a system like LEED that has to function in a commercial market. Even though the use of LCA tools may eventually result in reduced assessment costs, the reference constraint must first be overcome.

Ultimately, the answer is to develop case studies of different types of conventional buildings in different regions that can serve as benchmarks. That process is already underway in Canada and presumably in other countries with access to whole building LCA tools. But it is also time consuming and relatively expensive. And when the reference cases are developed, assessment system developers will have to determine how to score results for a specific building relative to the reference case(s). Not easy, but necessary.

5. CONCLUDING THOUGHTS

If a design team came forward with a building design that halved every number in Table 1, they would not receive a single point under the LEED system. We believe that must change. We must somehow overcome the reliance on often unsupported conventional wisdom, especially with regard to building materials, and focus instead on rewarding designs that truly result in reduced environmental burdens. Despite its limitations, LCA seems to offer the best potential for achieving that objective.

There are certainly constraints to be overcome, principally with regard to the availability of fundamental LCI data and the development of appropriate benchmarks for judging and rewarding environmental improvements. In the meantime, the developers of building rating and assessment systems can take positive steps by becoming more conversant with the principles and practice of LCA, and with the tools that are already available to help in the application of LCA. However, system developers must also exercise caution, and maintain a clear distinction between the apparent merits of individual materials or products and their use in a whole building context where they may function differently or have broader implications.

In the long run, the integration of LCA tools into whole building assessment systems will yield significant benefits, not only in improved understanding and crediting of environmental performance, but also in reduced assessment complexity and cost. The focus will have shifted off conventional wisdom, and detailed documentation of related purchasing decisions, onto a more robust objective function — the minimization of life cycle flows from and to nature.

European Eco-evaluations of Construction an Italian Approach

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Although recent development on eco-sustainability evaluations has led to more precise and sophisticated solutions, a clearer focus on their practical introduction and application has slowly faded. Furthermore evaluation tools alone cannot fully control all environmental impacts derived from construction.
The system proposed in this paper is an instrument thought for both Designers and Local Administrators to offer an environmental control throughout the entire process focusing on global impacts. The evaluation tool is comprehensive and user-friendly to allow several uses through the design/approval process and to better integrate with new sets of requirements in Building Regulations.

1. INTRODUCTION

Within the European scenario on eco-sustainability evaluations developed in recent years, we now have a variety of tools through which it is possible to certificate the grade of eco-compatibility of buildings. Although their methodology apply directly to buildings, many environmental impacts are left uncontrolled since several other factors may influence the ecological balance on the immediate surroundings or in different ways on men's health. Those can be due to the existing ecological asset of the site (i.e. biodiversity, pollutants of diverse origin, natural drainage etc.) or to the quality and salubrity of construction components.
This framework still allows many aspects to be subordinated to the designer's discretion and not necessarily evaluated and prevented. Morover the insertion of such tools within the existing legislation is still far from being formulated and experimented.

2. SR.V – SISTEMA REGOLAMENTO.VALUTAZIONE (REGULATION.EVALUATION SYSTEM)

The SR.V is an instrument that combines sets of rules and requirements with an evaluation tool in order to control comprehensively the *bio-ecological quality of the project*. It has been specifically thought to find its location as an additional step within any given Building Regulation (Table 1).

Table 1 Introduction of SR.V (section V) within a typical Building Regulation.

I.	General provisions;
II.	Procedural rules before construction;
III.	Procedural rules during construction and at end of works;
IV.	Particular rules;
V.	*Rules and tools for Bio-Ecological Quality control*
VI.	Final provisions.

Through this more comprehensive methodology, Architects/Engineers and Local Administrators can prevent a wider range of unsustainable patterns in construction by a user-friendly platform that gives a common ground to work on. In this way planning approval follows the design process during each stage through prevention and eco-incentives. The evaluation tool becomes a core element, and not the sole, whose function is to minimize *global impacts*, measuring resources, and energy consumption of the building during its lifetime.
This type of control consists of five steps covering three main areas: *site, ESA and user* (Fig. 1). The first –site– deals with local impacts of the building on the surroundings and viceversa managing issues related to *Ecology* and those to *Morphology*. The second –ESA– is a simple evaluation tool that balances the net consumption of resources, through quality parameters, energy and costs during the whole lifecycle. At last –user– deals with direct interactions between the building and men controlling *Safety* and *Quality* of building components and services adopted within a certain context.

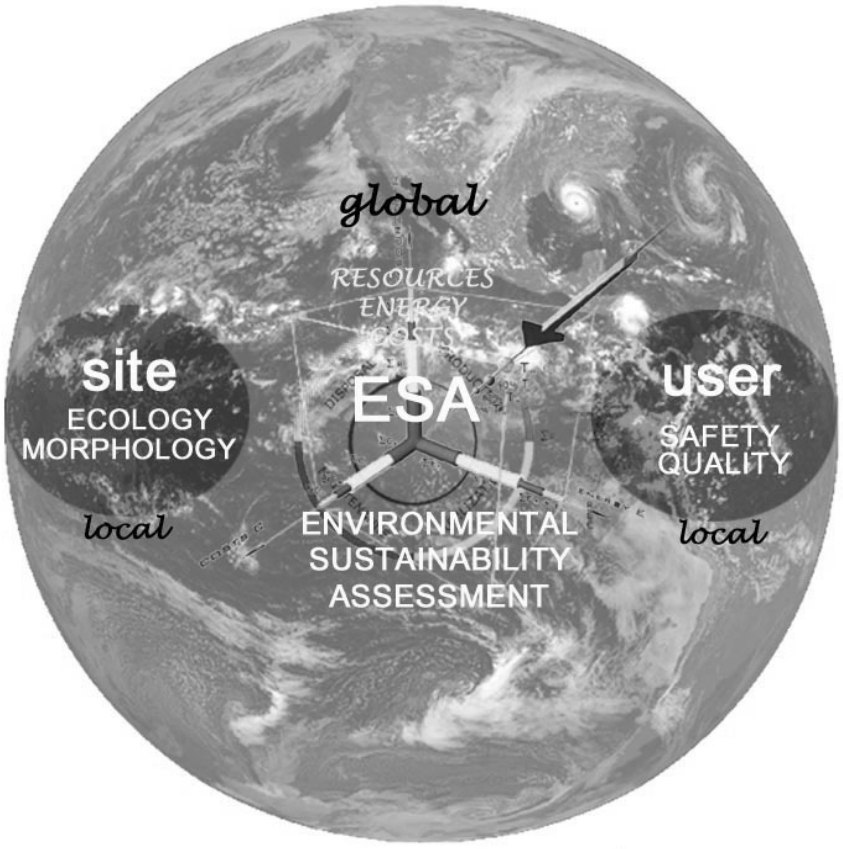

Figure 1 Overall layout of SR.V.

The layout in Fig.1 shows both the Architect/Engineer and the Local Administrator the path to follow in order to direct the building towards the least impact possible. Each step must be passed succesfully in order to continue to the next, even though steps back are compulsory when considerable changes will take place during the design process. Flexibility is allowed but the project must be verified at all levels. Two sets of incentives will encourage ecological solutions at both global (ESA) and local levels (user).

2.1 Site - Ecology

Any human transformation or insertion within a territory need to be verified by an holistic approach to protect and implement existing conditions of living ecosystems:

Biodiversity
Landscape as an "heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout"(Forman R.T.T., Gordon M. 1986) has structure, functions and transformation dynamics. Landscape ecology models based on the General Theory of Systems can identify existing and potential elements contrasting the equilibrium.
Ground
Any transformation on the territory shall be read by natural engineering techniques to protect from ground erosion, underground water and preventing idrogeologic impairment through the use of systems composed by plants and construction materials (stones, earth, wood, steel)
Pollution
Complete cartography and databases can identify differnent classes of potential harm due to radon gas, radioactivity, elettromagnetic fields (static and alternated), geopatogenous interference, direct and indirect noise etc. assigning to each preferred solutions to adopt.

2.2 Site - Morfology

Local data have directed project proposals to construction typologies and locations compatible with the area and mitigated impacts on eco-cycles and men. An other set of requirements controls all interactions with the existing built environment:
Historical buildings
A diacronic analisys allows to read historical configuration models and their potential decay. The morfology of urban textures, read by parts (Moneta G. 1992), shows structural and typological qualities on which verify possible scenarios of strategic intervention in conservation or restoration.
Urban growth
A sincronic analisys identifies creation and transformation mechanisms of systems and subsystems showing incoherent tendencies of development. Modification of homogeneous urban spaces is monitored leading to an integration of residential and other activities.
Proposed project
Within a proposal particular attention is given to social and private spaces and their connections, diversification of typologies and pedestrian pockets.

2.3 Environmental Sustainability Assessment

The structure proposed for the Environmental Sustainability Assessment (ESA), is based directly on the Life Cycle (Atkinson et al., 1994; Ciambrone, 1997), and analyzes every moment of the useful life of a building according to the temporal divisions adopted by Bosco Bueler in his "Swiss Roll"[1]. (Fig.2)

The environmental sustainability requires measurement of the following flows: the *total amount in tons of resources – R*, influenced by correction factors expressing their ecological quality; the *total amount of energy consumed in GJ – E*, of both embodied energy of building materials and the average energy requirement per year of the building itself; and the *total costs – C*, independent of who bears it, for the construction, utilization and the disposal of all components.

The interpretation of the aggregate result of these flows is based on the simple premise that, the smaller and slower are these flows, the better the quality of the environment. Elrich-Holdren's important equation measuring environmental impacts (I = P x A x T) was first published in *Science* in 1971 and presented the fundamental basis for an environmental control: the total consumption of goods per capita and their environmental impact per unit is directly proportional to the total environmental impact produced.

[1] Product Eco-label, endorsed by the first European Eco-labelling Conference (1995). See ERG, 1996.

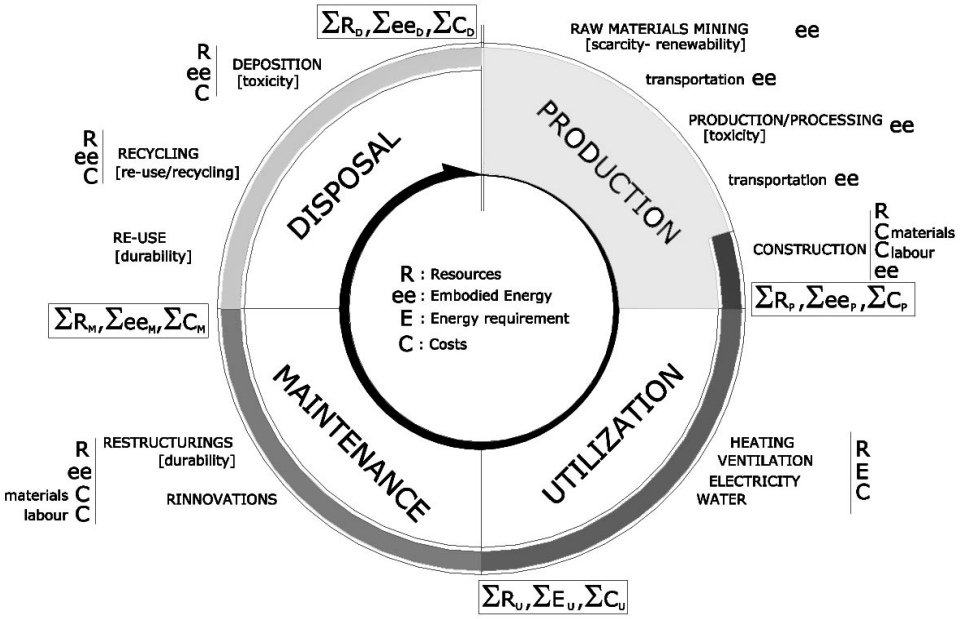

Figure 2 Life cycle assessment applied to buildings.

According to this method, the technological quality (T) is described by the corrective factors that express the impacts of the resources based on global data, multiplied by the actual amount used (A). In our case, resources are subdivided in Primary – P which compose the actual body of the building, and are found only during the phases of production and maintenance, and Accessory – A which represent instead the flows indirectly generated by the former (fuels, water etc.) and belong to each phase of the life cycle.(Fig.3)

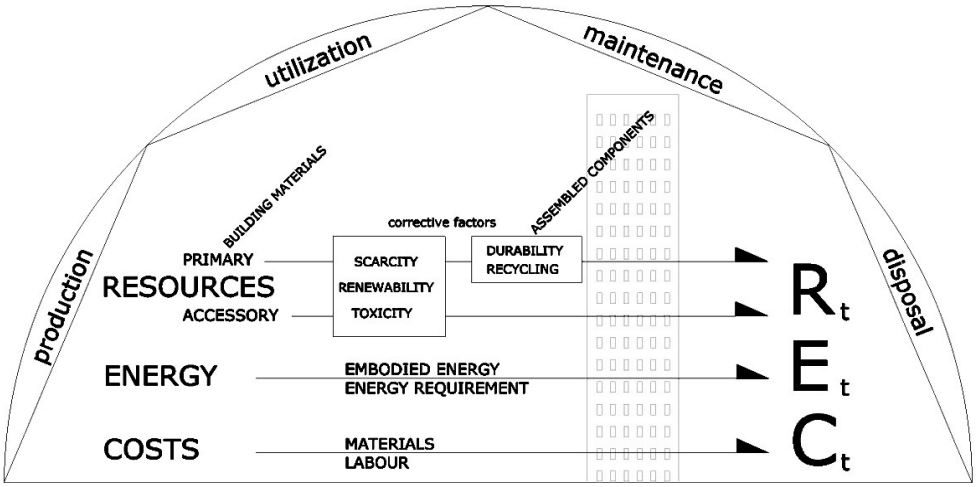

Figure 3 Primary flows due to construction during its lifetime.

The architect/engineer must be able to verify, at each stage of the design process, that the overall effect and performance of all building elements will in the end produce a positive result. It is also necessary to identify which are those factors that make the project environmentally unbalanced.
Once the total values of resources R, energy E, and costs C have been calculated, they will be inserted into a Cartesian space (Fig.4) where it will be possible to identify the point Tm whose

distance from the origin represents the *Environmental Sustainability Index* (esi). This value will be measured in relation to the total amount of cubic meters of actual construction (V), thus providing a basis for benchmarking between different-size buildings with similar functions. The average cubic meter of construction can be built using no more than a given amount (Tm) of R-E-C. The smaller this value, the higher the sustainability grade.

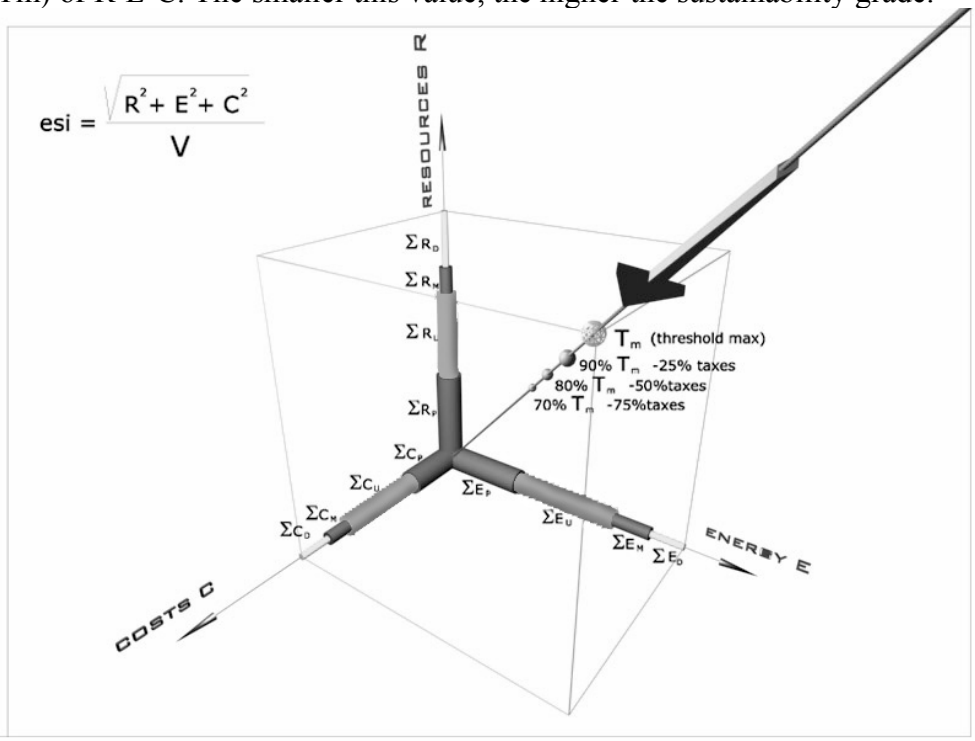

Figure 4 Environmental sustainability index calculation (esi).

2.4 Safety

The requirements to be met for this phase refer to the structural stability of the proposed project in direct relation to the local geology and foundation typologies, to fire prevention and reliability of systems and plants.

2.5 Quality

According to directive 89/106 CEE the project should be conceived with technical and design solution in order to not compromise the user or neighbor's health. A second set of incentives applied to preferable typologies coordinates the approval for the following issues:

Hygiene:

i. Discharges of waste water
ii. Discharges of solid waste
iii. Systems for reuse/recycle

Health:

i. Toxic emissions from materials/finishes
ii. Internal humidity/ventilation/ illumination
iii. Internal electromagnetic fields

Materials:

i. Certifications of materials
ii. Certifications of assembly typologies
iii. Durability

3 CONCLUSIONS

Buildings can be sustainable first by wisdom then by knowledge. While we wait for those qualities to be more widespread among professionals and users we need to find simple and efficient ways to mantain the whole process of construction within certain limits.

The innovative aspect of the proposal (currently under monitoring in Ariccia-Rm, and Vezzano Ligure-Sp, Italy. *http://www.iris.ba.cnr.it*) lays in the uniformity and cohesiveness of a system package thought to be directly inserted within existing legislation. Environmental protection will be able to grow organically from the drawing board to the Corporation Offices through a compatible flow of informations.

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Reducing Energy & CO2 Emissions - Impact and Opportunities attributable to Australian Suburban Dwellings

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1.0 INTRODUCTION

On a per capita basis, Australia's contribution to global CO2 emissions is one of the highest among the OECD countries. The residential sector contributes to nearly one fifth of the national greenhouse gas emissions. Almost all of this is attributable to the operation of the dwelling such as space heating/cooling, hot water, cooking, lighting and domestic appliances. Consequently, most of the efforts at energy conservation in residential buildings in Australia have focussed on reducing the operational, or direct, energy use by residential buildings. In the recent times attention has also been directed towards indirect sources of energy use and CO2 emissions from buildings, with the energy embodied in building construction being attributed a more important role than previously thought (Energy Efficient Strategies, 1999).

This view, however, is still limited to an individual dwelling and its site. When a wider systems view of a house within the overall urban built environment is taken then more opportunities emerge. The urban built environment is serviced by a comprehensive network of life support systems such as the supply of water, food, energy, disposal of wastes, transportation, etc. that are currently centralised and consume energy derived from fossil fuels. While most work in this regard recognises the influence of the urban built environment on the energy & CO2 impact of some of these systems (Trainer, 1995), the impact of the latter has been rightly attributed to the proper functioning of the former (Rodger, 1991 & 1994). Considering two of these systems - water supply and sewage systems, quantitative assessments have focussed on them independently without any relation to the built environment and have considered mainly the operational energy of the system such as that in water or sewage treatment (Sydney Water, 1998). The need for a more comprehensive analysis of water and sewage systems that includes indirect energy sources has been raised (Hagan et al., 1980). Pullen et al. (1998) take such a comprehensive approach and also relate the impact to the built environment. However, apart from these isolated studies, the impact attributable to buildings due to these systems can still be considered as a relatively unexplored area.

Such a wider view of the impact of the built environment has been adopted for residential buildings in Australia and a preliminary quantitative investigation into some of the life support systems on a pilot case study has been undertaken earlier (Divakarla et al., 1991). In this paper, an attempt is made to provide a more detailed and systematic quantification of the CO2 contribution of the water supply and sewage disposal systems on a full-fledged case study of a typical Australian suburban dwelling.

2.0 METHODOLOGY

In order to achieve the aim of the study, a typical suburban house with a 4-person household in the northwestern suburbs of Sydney was chosen as a case study. It is about 122 m^2 in size, of brick veneer & tiled roof construction and occupies a 760 m^2 site.

2.1 The Framework and System Boundaries for Energy Analysis

The energy and related CO2 emissions associated with the systems are considered over two life cycle stages - initial creation of the infrastructure and then the continuous operation of the system. A typical 100-year life of the house is assumed for the analysis.

The framework employed is based on the model described by Treloar (1998) in which embodied energy comprises a chain of direct energy requirements. For any given process under consideration, there is a direct as well as an indirect energy component. For example, if the manufacture of steel is being considered (level 1 process), the direct energy is that used at the manufacturing plant. The indirect component includes the direct energy for the immediate upstream processes (level 2 processes) associated with the inputs into the steel manufacture. The level 2 processes in turn have direct and indirect energy components and the pattern continues indefinitely.

The system boundary for quantitative analysis depended to a great extent on the availability of information and is as follows :

- Water supply system : *Infrastructure* (1st level - dam construction; 2nd level onwards - materials used in water collection, storage, treatment and pipework for transportation); *Operation* (1st level - water collection, storage, treatment and distribution; 2nd level - chemicals manufacture)
- Sewage Disposal System : *Infrastructure* (1st level - construction of wet weather storage tunnel; 2nd level onwards - materials used in sewage transportation and treatment); *Operation* (1st level - sewage collection, treatment and disposal; 2nd level - chemicals manufacture)

2.2 Embodied CO2 Coefficients

The embodied CO2 coefficients (energy related) of the construction materials are adopted from Treloar (2001). These are derived on the basis of hybrid analysis that takes advantage of both process analysis and input-output methods. The embodied CO2 coefficients of the chemicals have been calculated by the authors from literature on the process energy requirements for the manufacture of the chemicals.

2.3 Apportioning CO2 Emissions to the House

The approach adopted for the water system is different to that for the sewage system. For the water supply system, the impact of individual components along the particular path servicing the

house was determined and apportioned on the basis of their respective flows. This required relatively less information. For the sewage system information on such individual flows through the components was not available. So the entire system and total flow within the system were considered and a proportionate amount was attributed to the house.

3.0 RESULTS

3.1 The Water Supply System

The water supply to the house begins its journey from the catchment. It is then stored in the dam. From there it is transported to the water treatment plant through 2 large pipelines. A pumping station pumps the purified water into a water main that carries it to the service reservoir where it is temporarily stored. It finally reaches the house through the local distribution mains.

3.1.1 Infrastructure. There are embodied energy implications with :

- Water storage in the Burragorang valley - The submerged Burragorang valley was cleared of all timber and vegetation in advance of the rising waters. Up to 500 men were involved in this operation, felling timber that was disposed of, or stacking and burning the timber which involves the direct use of energy as well as that embodied in the tools used.
- The Warragamba dam - It is the largest concrete dam in Australia comprising about 3 MT of concrete. During the 15 years of construction period the river was diverted through a large concrete lined tunnel. In order to speed up and control the cooling process of the concrete, chilled water through 64 km of mild steel piping was circulated through the structure. Special refrigeration plants were set up on the site for this. The nearly 0.3MT of cement was transported by road from another town and the aggregate was transported via steel cables and towers 20 km away.
- The Warragamba Township - It was built for 3, 500 people that included the workers involved and their families.
- Pipework - Almost all of it is of steel with cement lining. The service reservoir is also constructed of steel walls with an aluminium top. All these materials are very high in embodied CO2 coefficients.

3.1.2 Operation. The energy involved in the operation is mainly in the pumping of water. Energy is also involved in treatment of water and in the operation of the dam as well. Energy and CO2 emissions are also involved indirectly in the manufacture of the 7 different chemicals used in the treatment process.

3.2 The Sewage System

The sewage from the house is transported through pipes via gravity. There is no pumping of sewage involved in the particular path servicing the house although there are sewage pumping stations in the system. The sewage is then treated at the sewage treatment plant. An extra component (Northside Storage Tunnel), not common in sewage systems, was included in the analysis. The tunnel was built recently to address the pollution of Sydney Harbour due to spillage of diluted sewage during wet weather.

TABLE 1 Energy and CO2 emissions associated with the water and sewage systems

Contributing sub system	Total CO2/ML (kg)			% of CO2 of total system		
Water Supply	*Infrastructure*	*Operation*	*Total*	*Infrastructure*	*Operation*	*Total*
Collection	0.0	0.0	0.0	0.00	0.00	0.00
Storage (dam)	18.7	1.5	20.2	2.59	0.21	2.80
Treatment	10.0	71.5	81.4	1.38	9.92	11.30
Transportation	227.6	391.3	618.9	31.59	54.31	85.90
Total Water	***256.2***	***464.2***	***720.5***	***35.57***	***64.43***	***100.00***
Sewage						
Transportation	118.5	80.8	199.2	18.69	12.74	31.43
Treatment & Disposal	10.9	423.9	434.8	1.72	66.85	68.57
Total Sewage	***129.4***	***504.6***	***634.0***	***20.41***	***79.59***	***100.00***

TABLE 2 CO2 emissions attributable to the house from the water and sewage systems (Based on 1000 l/day water use; 800 l/day sewage production; 12373 kWh/yr energy use; 60% gas & 40% electricity use for a combined gas/electric house)

Life supporting system	CO2 contribution from infrastructure/ 100yr (t)	CO2 contribution from operation/100 yr (t)	Total CO2 contribution to house/100 years (t)	% increase over CO2 of all electric house (%)	% increase over CO2 of gas/electric house (%)
Water supply	10.2	18.6	**28.8**		
Sewage disposal	3.8	15.0	**18.8**		
Total	**14.1**	**33.6**	**47.7**	**4.0**	**7.8**

3.2.1 Infrastructure.

- The sewage is transported through a network of over 6000-km of pipes. Many sections of the sewers are concrete lined tunnels through sandstone. Tunnel construction, as is the practice nowadays, involves significant inputs of electrical energy. Calculations on the CO2 from the construction of the 20 km long North Side Storage Tunnel, has shown that for the 4-6.5 m diameter tunnel, about 8 tonnes of CO2 emissions were released per metre of the tunnel.
- Most of the pipes are manufactured in Australia. However, clay pipes are purchased from Belgium. The energy and related CO2 emissions due to the transport of clay pipes, considering they form a high proportion of the total length of pipes in the system, would be quite significant. In sewage treatment too this is the case where although only 10% of the

pumps are purchased from overseas, they need to be replaced between 4-20 times over a 100-year period.

3.2.2 Operation. Most of the energy use and resulting CO2 emissions are due to sewage treatment. The operation of the wet weather storage tunnel also involves some energy for pumping the sewage (towards the sewage treatment plant end). Energy is also involved indirectly in the manufacture of the 6 chemicals that are used in sewage treatment.

4.0 DISCUSSION & CONCLUSIONS

On a per unit volume basis of water or sewage serviced, the total emissions from the water supply system are more than those from the sewage disposal system. From the point of view of operation vs. infrastructure, the CO2 emissions due operation are higher in both the systems. However, emissions from the infrastructure are also quite significant, particularly in the water supply system (36%). This can be explained by the predominant use of steel for pipes in the water system, whereas in the sewage system it is mainly concrete or clay. Considering the various stages in the system, the emissions due to treatment and disposal are highest (69%) in the sewage system, while emissions due to transportation are highest (86%) in the water supply system. Considering direct vs. indirect CO2, the former forms only about 62% and just over 77% of the water and sewage systems respectively. This comes as quite a surprise since most studies on these systems consider only the direct operational energy.

In addition to the comparisons and contributions shown in the tables, it can be said that it takes about 4 years for an all electric house and about 8 years for a gas/electric house (for the same case study dwelling) to emit as much CO2 as that due to the sewage and water supply systems combined. While the operational energy and CO2 emissions of the house are still the dominant contribution from the house, viewing the bigger picture, the absolute emissions and the increase over the operational CO2 emissions is quite significant. Increasing the system boundaries for analysis and including more of the life support systems will further increase the contribution of a dwelling towards the greenhouse effect. Contribution to the greenhouse effect will also increase with other emissions (such as methane) from the sewage system.

From the point of view of reducing these impacts in this case, addressing the water supply system may be more beneficial as its impact is higher. There are opportunities for improving energy efficiency in transporting water, including the infrastructure. There are also opportunities for alternative water systems at the level of the individual house, such as rainwater harvesting. This avoids the entire transportation of water that involves the greatest impact, in addition to the impact due to treatment of water too. However, in order to make an accurate evaluation, a comprehensive embodied CO2 analysis of the rain water tanks needs to be made. From the point of view of sewage treatment, improving energy efficiency in the treatment process as well as alternative options at the level of the house, such as reed beds with low embodied and operational CO2, can result in CO2 reductions.

This study provides an initial indication of the impact of the life supporting systems of a dwelling and opens the way for conducting similar investigations on other dwelling types and other life supporting systems in a structured way.

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Three Visions Of The Future Urban Environment In Australasia

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1. ABSTRACT

The way we use buildings, the materials and technologies used in construction, and how the buildings themselves are designed and constructed are continually evolving; the built environment evolves with them. It is a commonly held view that this pace of change will accelerate in the foreseeable future.

Scenarios are very useful devices for organising a large amount of seemingly unrelated information in a logical manner to stimulate discussion and learning about the choices that lie ahead. As part of long-term forward planning for the building industry of New Zealand, the Built Environment team at the New Zealand Forest Research Institute Ltd has generated a set of three thought-provoking and realistic scenarios to show what the Australasian urban environment might look like in 10–15 years' time. The scenarios have been built from a very broad information base, and are generic enough to be useful to, amongst others, urban planners, property developers, and strategic planners in the construction, forestry, energy, and transport sectors. The scenarios can be used to both inform and evaluate future strategies, plans or projects and as a means to better understand what is happening in the built environment.

Whilst the scenarios have been built from a broad base of background data, representing global trends, these data have, of necessity, been filtered to include only those trends which are likely to be significant in terms of the future Australasian built environment. The three scenarios consist of a continuation along the present urban sprawl trajectory; a movement towards sustainable, higher density urban landscape; and a focus on regional development and the formation of satellite cities.

This paper sets out to explain the three scenarios, what the key drivers would be to spin the built environment along the three divergent paths, and some of the implications that arise from the various outlooks.

2. INTRODUCTION

Separate houses are the most favoured form of dwelling in Australasia, there being an historic tradition of owning large areas of private space in these countries. Consequently, over the past 50 years Australasian cities have grown rapidly in area along a conventional pattern of suburban development geared around single dwellings and individual car ownership. The limiting factor is amount of space available for new building development. Without space limitations, consumer desire for consumption and size triggers a move towards sprawl. However, if space is limited, local covenants may push a move towards SmartGrowth

development, using brownfield sites and reusing space and materials. Both can happen in a regional development context, depending on vacancy and redundancy of buildings and available space to expand.

Where space for expansion is now at a premium there is a push for higher density housing developments. However, while there has been some shift among first home buyers (young single adults and couples) towards higher density housing, consumer preference is predominantly for larger single dwellings on smaller sections. Indeed, while families are getting smaller, new homes are getting larger.

3. THE THREE SCENARIOS

Scenarios are very useful devices for organising a large amount of seemingly unrelated economic, technological, competitive, political, and societal information in a logical manner and stimulating discussion about the choices that lie ahead[i]. They do not pinpoint future events; but highlight the major forces that could push the future in different directions. Our future built environment will be shaped by the way we live, work, and play — technology, consumer preferences, fashion, social values, and lifestyle choices are all factors here. Three scenarios were developed, each of which paints a plausible picture of the future built environment. No one story will be completely right or completely wrong; it is likely that certain elements of each will be accurate. Likewise, each scenario contains positive and negative aspects — none is entirely rosy and none is entirely dark. The scenarios need to be viewed as a set for strategic decision-making purposes.

Pre-determined elements such as population growth, urbanisation and globalisation, continued resource and energy use and the growth of IT became apparent when analysing key trends. These elements are firmly established along a particular trajectory and are completely outside our control. They are the same in all scenarios. In conjunction with these, *critical uncertainties* emerged, the effects of which could drive the urban environment in varying directions dependent on the way these evolved. Many things are uncertain, but the critical uncertainties are those that are central to the focal issue of the exercise and are impossible to predict. All uncertainties seem unique to start with, but they can usually be grouped.

In evaluating the key drivers of change, a clustering process revealed three natural groupings of critical uncertainties, the consequences of which would spin the urban environment along three divergent trajectories from its present course (see Fig 1 overleaf).

3.1. Scenario 1: The Renaissance

In this scenario, growth of the green market, the uncertain and volatile energy market and increasing viability of alternative energy sources spin the urban environment along a SmartGrowth trajectory to conserve resources and plan effectively for future use. As the world population increases, and land resources are tightened, more urban dwellers need to be accommodated on less urban land space, unless cities are allowed to occupy fertile land in outlying areas. Houses in Australasia are investments, the building market is being squeezed by margins, forcing builders to erect quickly, and use cheap, labour-saving building products.

The depletion of hydro lakes, diminishing natural gas fields, and fluctuating oil prices together trigger a wake-up call to the squeeze that exists now. The uncertainties surrounding

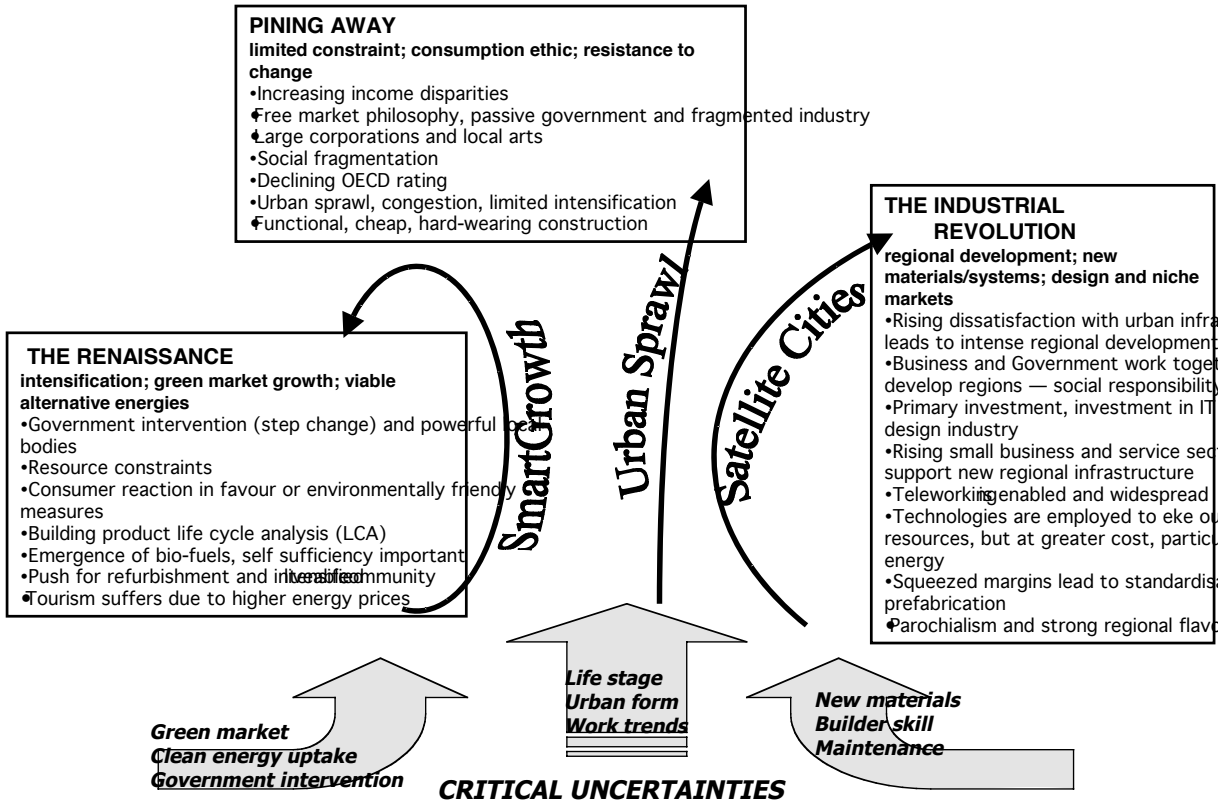

Figure 1 Clustered Critical Uncertainties showing Divergent Trajectories

energy (supply, cost, consumer behaviour, efficiency, alternatives) and the 'green consumer' form the basis for this scenario. Forward planning, a shift towards alternative energy schemes, and infrastructural changes led by a strong government allow New Zealand to successfully manage resources and yet retain a clean green image. Continuation of current consumption trends will exacerbate adverse environmental impacts, so the Government and public authorities are given a mandate for change through mounting public pressure. The major uncertainty is whether the regulatory authorities will respond by imposing energy efficiency and conservation measures through a prescriptive, legislative framework, or by providing incentives to consumers through, for example, star -rating systems.

The uncertainty of consumer response, as to whether legislative means is the only route to sustainability, or whether consumers will voluntarily seek sustainable solutions because of an impending crisis may see environmental gains achieved through new design tools. These may include widespread adoption of new design procedures which model the "through life" costs to improve value for customers and improve economic and environmental performance. Specific environmental trends include:

- cleaner processing technologies, reduced emissions, discharges and solid wastes;
- efficient, low emission and sustainable energy technologies;
- life cycle evaluation and analysis, including environmental impact, changing use and lifelong support, and disposal and decommissioning.

Factors which may propel the growth of the green market include: increasing concern about the environment and health; an affinity for wood; the push for zero waste management, energy efficiency and reduced greenhouse gas emissions; and effects of climate change. Some constraints are: the high price and perceived low quality of green products; availability of green products to the public; the ability and willingness of builders/developers to incorporate

energy efficiency measures and deliver green solutions; and the ability and willingness of consumers to conform to Government regulations and green market incentives.

3.2. Scenario 2 : Pining Away

Under conventional urban form there is a natural momentum for outward expansion, given: urbanization; demand for living space; desire for space and acoustic privacy amongst young families; a heritage of large private space in Australasia; increasing land values; central offices; established infrastructure; the investment nature of property; and independent means of travel (car culture). Conventional urban form may thus be interpreted as an established culture, with a consequent reluctance for change to intensified developments. Perceived social problems arising from higher density living, together with stories relating to poor quality developments, which heighten the natural resistance to change[ii]. Continuation of present lifestyle and consumption trends would favour sprawl yet limited space, escalating land values and traffic problems are forcing local governments towards more sustainable policies[iii]. The choices that will be made will be influenced by the actions of local government and developers, work trends and variations in the life stage requirements of consumers.

The continued desire for space and avoidance of inner city traffic congestion has seen the relocation of malls and offices to the outer suburbs and a proliferation of lifestyle blocks[iv]. There are now about three times as many lifestyle blocks in New Zealand as there were in 1985. This development is aided by greater job flexibility and infrastructure, allowing more people to work from home and still be within a comfortable drive of major business centres. Under this scenario, despite the apparent problems with urban environments and infrastructure, a general resistance to change and a prevailing desire for free choice and independence, see the present patterns of consumption, comfortable lifestyle and urban sprawl continue, placing strain upon roads, utilities, the natural environment and health. Conditions for a culture change to intensified development do not develop in the 10-15 year time horizon in this scenario, thus infrastructure in the large urban centres come under increased pressure. Although these areas find themselves increasingly stressed and stretched to capacity, the rural areas and smaller town centres of New Zealand will not be as affected, finding life very much the status quo. Emphasis is primarily on consumer choice, with the market providing ad hoc solutions to infrastructure and environmental problems as they arise.

Major uncertainties surrounding the move to increased urban sprawl surround our ability to supply increasing energy demand; land use and zoning; the ability of existing infrastructure to cope with increasing amounts of traffic, waste generation and environmental stress; lifestage and required urban form; and work trends (flexible work hours, teleworking, commuting ease, etc.)

Factors which may continue the momentum include perceived available space for subdivisions; perceived urban opportunities from a move to the larger centres; consumer demand for single unit dwelling and home ownership; and increased property prices and perceived return on investment. Constraints which could turn the tide will be a continued commitment from local bodies and developers to create more liveable communities, infrastructure or resource crisis causing a substantial change to consumer attitude and behaviour, and a desire to live in a smaller centre, or closer to workplaces due to long commutes.

3.3. Scenario 3 : The Industrial Revolution

In this scenario, our determination for the New Zealand nation to grow in economic wealth

sees a Government and Industry leadership drive, resulting in new investment, in technologies that make smarter use of resources. The uncertainties around material resource usage, wood performance, builder skills and maintenance of existing housing stock form the basis of this scenario. Several core elements (growing dissatisfaction with urban life, increased regional industry and infrastructure, and the freedom of teleworking) allow the natural progression of regional development to ensue, in this case through the growth in nearby satellite cities, in order to reduce the infrastructure and population pressure of the very large urban settlements.

A major uncertainty is around obtaining the investment needed to process and value-add primary sector produce, and also the ability of the 'Knowledge Wave' to take off, allowing newer, smarter ways to eke out the existing energy and materials whilst still allowing some level of environmental discipline. Architecturally designed one-off housing was estimated at just 5% of new New Zealand dwellings in 1999[v]. The growth in factory-processed and prefabricated building systems, combined with registration of builders and consolidation from squeezed margins furthers the design-build proliferation of affordable mix-and match buildings.

Elements of change forming the basis of this scenario surround sustainability of material resources; affordability of our housing stock, particularly in Auckland, Sydney and the growing Sunbelt regions (the Gold Coast, Bay of Plenty, Nelson and the Kapiti coast); and the level of builders' skill with the growing number of systems available. Other uncertainties arise around the suitability of our present wood resource to meet the performance needs of consumers, and what new technologies will allow in the way of materials development and increased alternative products, and how we retrofit our existing regional building stock. Presently, there are 26,000 new residential dwelling units built per annum, while the overall housing stock is 1.4 million units[vi].

Factors which may propel the building industry into new technologies, building processes and quality systems are training and registration of builders, increasing margins, supply of resources and resource sustainability, increased consumer and regulatory performance requirements, and changes in lifecycle usage, and life cycle analysis of buildings. Constraints include investment into and uptake of new materials science, toxicity and zero waste push, education level, and energy supply.

4. IMPLICATIONS FOR THE FUTURE AUSTRALASIAN URBAN ENVIRONMENT

4.1.1 ***The Renaissance*** -A major paradigm shift in leadership, lobbying and strategy are pre-requisites for success as society is pushed into a culture change, particularly in energy use. As the green market and the accompanying regulations become mainstream, natural materials would enjoy increased market share. There would be significant opportunities for clean, green branding and passive design solutions. Instability in the price of energy may deter consumption and through Government subsidies encourage the emergence of alternative energy sources such as photovoltaic and fuel cell technologies. Mass transport use would therefore increase significantly (but personal transport would not entirely disappear). The IT and telecommunications industries would become increasingly important as travel becomes more selective. Adherence to the Kyoto Protocol and Agenda 21 will bring about significant changes in New Zealand's transport and building sectors. There would be significant research into technology solutions to ease the effects of restrictions. Medium-density housing would become more acceptable. Should the international trend to teleworking be strongly adopted in Australasia, many existing households will require remodelling, and workers can

consequently live further away from the city centre, eroding the requirement for large downtown office buildings.

4.1.2 ***Pining Away*** - Inadequate forward planning will see people lulled into a false sense of security as they have not foreseen the need to change their behaviour. The philosophy of free choice, with limited restrictions and limited consequences would be viewed as advantageous by many. The expected increase in demand for smaller houses in traditional retirement locations, coupled with a decrease in demand for larger family homes may not occur. Householders nearly always want more space, and one- and two-person households may prefer rooms such as home offices and exercise rooms. Australia and New Zealand will continue to have more available space for migrants than traditional source countries. Migrants will be attracted to the big centres, which will continue to get bigger, and although good for infrastructure providers and employment opportunities, lack of space for "green field" development would see outlying fertile areas and parks zoned for new development. Property prices in these areas will continue to be inflated, as people struggle to afford housing leading to large mortgages and to the attraction of standardised, cheap bulk construction through design-and-build development firms who offer low deposits. Increasingly stretched infrastructure in large cities would result in overload, chaos and lost productivity.

4.1.3 ***The Industrial Revolution*** **-** Increased business activity in the regions would promote economic growth. There would be less stress on infrastructure in the major cities such as Sydney and Auckland due to the emphasis on growing satellite developments. This will ease stressed infrastructure but older, larger cities may struggle to afford upgraded amenities due to a slowdown in population growth (as is becoming the case with Dunedin[vii]). Relaxing the emphasis on environmental legislation is likely to result in tension between interest groups and big players. Given that consumers are unlikely to reduce their demands in terms of performance standards, quality, and quantity, opportunities to increase technological knowledge, skills, and productivity abound. An emphasis on smart processing and design paves the way for new products and new markets. Re-use and retro-fitting of existing buildings would open up opportunities for readily available, flexible, adaptable systems. Consolidation at all levels of the building industry is expected, and project management and modelling of building control systems will become common. It is anticipated that many firms will no longer be competitive if they do not become proficient in current IT communications, and that many future tenders will be handled entirely electronically[viii].

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From The Shopfront To The Street – The Future For Wooden Buildings In A Sustainable World

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1. ABSTRACT

In future, the wood-based products industry will be competing in a smarter construction environment that is increasingly technologically efficient, cost sensitive and market aware. The construction industry has a challenge from two divergent trends. On the one hand, the growing demand for convenient, affordable homes has encouraged standardisation of design, and rapid construction techniques, incorporating prefabricated modular systems. On the other hand, there is growing awareness of the wider implications of the sustainability agenda, and increased insistence by regulators and public alike to deliver buildings which perform to increasingly high standards, but have positive environmental and social benefits. Wood-based products have the capacity to address both these trends.

This report explores our understanding of the major criteria identified for future buildings, in order to gain a good background understanding of the implications for wooden building practice in the context of a more sustainable world.

The major criteria for future buildings were identified as: Intensified developments – (medium density housing, generic construction and aesthetics, loss of consumer voice and neighbourhood interaction); Prefabrication – (quick assembly and erection, component tolerance, performance expectations, low-impact construction); Multi-functional use – (tenancy, enabling features, space limitations and shared occupancies); Customisation – (inequality and aspiration, personalisation, changing demographics and lifestyles, heritage and cityscape); Retrofitting and deconstruction of existing building stock.

Although traditional timber construction has been proven as a sustainable, renewable construction system, there remain social, institutional and technological barriers arising from these future criteria. In particular, the construction industry must consider how these needs can be incorporated through sustainable building design and development practices.

2. INTRODUCTION

Wood products currently play a dominant role in residential housing structures in Australasia. Currently, 94.1% of new residential houses in New Zealand are timber framed. However, this position is not assured, and certain trends and drivers[a] are forcing the timber-frame construction industry to re-examine the attitude that building homes from traditional 2x4" plantation timber will fully meet global sustainable development goals.

The principles that New Zealand puts forward as criteria for sustainable building[i] are:

[a] Demographics, lifestyle, new materials and systems, regulations, energy and environmental concerns

- connecting to and working with local ecosystems;
- not creating problems for someone else, and minimising negative impacts;
- adopting technologies appropriate to local conditions;
- expressing the culture and ecology of the people.

These suggest that wood products should be a favoured option for sustainable building projects —provided that the design utilises timber to its best advantage.

During 2001, ***Forest Research*** developed three scenarios[b] which gave differing but plausible views of the future built environment[ii]. The first scenario postulates a continuation in the consumption ethic and traditional urban form; the second suggests spreading population and growing the economy through regional development; while a third involves a Government push for growing the green market and intensification of urban developments.

This paper aims to explore the implications of these scenarios in terms of the major differences in criteria for future buildings, and wood products being used in those buildings, in the context of the sustainable building agenda. The first section outlines the current sustainable development environment in Australasia, and shows the potential of wood, in particular Southern hemisphere plantation forestry, as a sustainable building material. In the second section our understanding of the future criteria for buildings is discussed, and the final section gives the likely impacts of both sustainable development and the future criteria for buildings on wood-based building products.

3. SUSTAINABLE DEVELOPMENT

3.1. Background

A sustainable development report from the United Kingdom's Housing Corporation[iii] included a report on timber-frame housing which concluded that the need to create more sustainable developments would drive the change towards specification of more renewable resources and "leaner" construction practices.

A recognition for this drive is beginning to occur throughout Australasia due to pressing urban issues. Issues that have come to the fore in recent times include: the unsustainable sprawl of Auckland and Sydney (a consequent push for Smart Growth and intensification initiatives has resulted); Government energy efficiency and thermal insulation performance overviews in Australasia (resulting in a move towards higher insulation and energy efficiency standards); meeting our commitments should Kyoto be ratified (presently New Zealand is expected to ratify the protocol); increasing consumer awareness of green issues, such as preservatives and resins used in timber manufacture, and FSC certified lumber; and social trends and demographics, such as changing family structure, aging population, rise in violent crime and the breakdown of communities. These combine to make the traditional three-bedroom single family home less likely to continue to dominate the urban landscape.

3.2. The New Zealand Situation

Construction and use of buildings has a large impact on energy and resource use, which is recognised by central and local government, however, there is a general acceptance that currently New Zealand sustainable development principles and practices within public and private sector organisations is less than adequate[iv]. The Ministry of Environment's

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[b] These scenarios are presented in a further paper at this conference, entitled "Three visions of the future urban environment in Australasia"

Environment 2010 strategy[v] has been criticised for not addressing and incorporating urban, social and economic interactions with environmental resources[vi]. New Zealand's hydro generated power supply and abundance of plantation timber have been viewed as contributory factors in the relative late participation in implementing sustainable development policy.

There are of course pockets of shining examples, as well as a recent gathering of steam in this direction, due in part to the Rio+10 World Summit. The New Zealand government is presently developing a National Sustainable Development Strategy, building on the Brundtland report of 1987. There is still little emphasis at local body level towards sustainable development strategies, and most of the emphasis is on in-house energy reduction. Waitakere, Christchurch and Hamilton City Councils stand out as the larger bodies trying to incorporate some measure of wider sustainable development in their strategies. There appears to be some consensus amongst building professionals and analyses by overseas organisations that the focus would sharpen and become mainstream within the next 2- 4 years, as the public and political climate gets more receptive to these ideas[vii].

3.3. The Wood Products Industry

Despite New Zealand's abundant timber supply, the forest management practices of large monoculture plantations and clear-cutting at a young age have been criticised for lack of biodiversity. Many of the world's old-growth forests are coming under increased public scrutiny, due to public perceptions (often true) about unsustainable management practices and illegal logging. The irony is that many promotional campaigns label all timber as unsustainable, and instead promote alternative, resource-intensive materials as being sustainable across-the-board. Southern hemisphere softwood plantations are, however, usually well managed, renewable resources of quality timber, and have the potential to replace non-sustainable timber from old-growth forests. Wood has a number of advantages compared to other products from a sustainable perspective. It is a naturally occurring, relatively energy efficient construction material, with good thermal and acoustic properties. A less obvious but compelling attribute for wood products generally is their affective element in an increasingly artificial environment[viii]. From a health perspective, there is evidence that wood-based environments contribute positively to both physical and mental health. Many hardware stores and Government policies now advocate FSC certified timber. Some major forest companies in New Zealand are FSC certified, and have the potential to exploit this situation by offering fully audited sustainably produced raw and manufactured product for global construction.

4. FUTURE CRITERIA FOR BUILDINGS

In this section, our understanding of the future criteria for buildings[ix] is discussed. The previous section has shown timber to have good potential as it is already well accepted in building developments from a sustainability context. Sustainable developments aim to provide a safe, nurturing environment through good design and appropriate material use. Of the future New Zealand housing stock in 2015, 85% has already been built[x], 62% of which were built prior to the 1977 insulation requirements and may still have uninsulated walls, and many use localised space heating. Most of the newer homes from the past decade are standardised design-build structures, some of which are already experiencing weather-tightness problems. Bringing existing building stock up to new sustainable regulatory requirements, particularly in the case of energy efficiency and durability, will be a major challenge over the next decade. Alongside these increased engineering performance requirements, there are also a number of building industry and consumer criteria which have been identified. These have been interpreted from a New Zealand context and are spelt out in this section.

4.1. Intensified Developments

Construction will be managed by larger firms, who have the IT systems, technology and communications to organise and integrate building components into a holistic unit quickly and efficiently. Systems design and integration will be needed to achieve a synergistic 'ecosystem'. Busier lifestyles and a rise in numbers of double income families see houses unoccupied for a greater proportion of the day, and occupants are increasingly looking for easy-care, low maintenance, secure solutions. Surface coatings which are long-wearing, easy to clean, fade resistant and healthy will be sought after, 'intelligence' in HVAC controls will emerge, as will 'Smart' coatings that interact with the environment. Increasingly, buildings will be centrally managed, with self-regulating HVAC systems throughout the building. Increasing emphasis on sustainable management practice will see developers and urban planners working in close collaboration with local authorities to optimise building use. Council policies surrounding sustainable development may require co-ordination and negotiation to obtain fully tenanted, longer tenanted buildings. This will require a greater deal of strategic planning, not just buying-up and developing any land available, and justification for buildings to gain building consent.

4.2. Prefabrication

Building site construction using sustainable principles should have minimal impact on surroundings and the environment. Construction teams will need to move on and off site quickly to give minimal disturbance, and the least environmental exposure to framing and components before closing in a building. Limited site access, especially for storage of materials and parking during construction will drive prefabrication. Prefabrication will be increasingly used due to increased speed of erection, minimal environmental impact both with waste generation and onsite land disturbance, greater performance through tighter tolerancing, and cost reductions through mass production. Prefabricated dwellings can lose a sense of individual style and design, due to the limited range of house-designs. By allowing different combinations of similar modules, in a mix and match sense, housing can have a greater range of combinations, and is better able to cater for individual needs and requirements.

4.3. Multi-Functional Use

Increased rental tenancy over home ownership is expected due to delayed marriage, and short-term employment contracts. A higher proportion of Polynesian and Asian peoples may increase inter-generational living, so multifamily housing complexes will need to cater for all ages and abilities. Housing requires areas which are both cocooning and invigorating, using individual add ons and finishes to give a personal touch, although the structures remain the same. Through use of a fixed framework, flexibility for creating individualised styles to rooms and interiors can be achieved.

Due to increased retail turnover, interior fittings need to be fixable, but non-permanent. Future enabling features include dividers, adaptable furniture, remote business and virtual transactions, with similar cocooning E-mail and reading areas, coffee breaks, seating etc. in shopping complexes.

Community buildings will be used by a wider variety of people, due to higher running costs, and a greater range of activities, resulting in clubrooms used as conference centres. There will need to be adequate sound barriers and a variety of space sizes for small-group and large audience meetings to occur at the same time. Security and storage will become very important due to multiple users. Commercial and retail buildings are also likely to have more shared space and resources.

4.4. Customisation

As population density increases, individualism becomes more important, particularly for interiors. Additions and added features will transpire due to new technologies and trends rather than due to functional needs. For example, a present trend in deck extensions and garden pergolas is due to desire for outdoor living rather than the need for greater space. The three bedroom house will be customised through incorporating rooms into entertainment studios, office space, or living areas via a large archway or removing a wall.

4.5. Deconstruction

Demolishing buildings and discarding materials is not only a waste of resources and landfill space, but a loss of heritage. As landfill space becomes scarce, and efficient use of energy and resources gains precedence, buildings will more likely be reused or recycled rather than demolished. Renovating with minimal destruction of materials and reuse of building components will see materials blended together through design to achieve the required level of engineering and aesthetic performance. The exterior is likely to remain intact, while the interior will change often with style, new technology and improved code requirements.

5. IMPLICATIONS FOR WOOD PRODUCTS IN THE BUILT ENVIRONMENT

The following table describes some of the most significant implications for wood products for future buildings, in accordance with the trends and criteria we have evaluated:

Wood products implication	Wood processing technology implication
Demand Increase in demand for value-added products in developed markets. Increase in demand in developing markets for traditional wood products. Desirability of wood as a construction material due to affective qualities	Development of high value, high performance wood products from sustainably managed forests, with lower cost traditional wood products. Increasing reuse of wood products in interior finishing.
Environmental issues Sustainable building products Toxic free components Zero waste production Environmental, energy efficient products that are healthy, and non-toxic	Re-cycling, re-using technologies in deconstruction of buildings, and re-processing components Life cycle analysis and green labelling of wood products Energy ratings for buildings Arsenate & chrome free preservatives, safe boric fixing technology Non-emission adhesive and coating technologies – especially for panel products will see zero formaldehyde and require more environmental coating products, in particular varnishes.
Wood supply Decreasing availability of tropical woods Decreasing availability of temperate natural forests Increasing availability of softwood plantations	Use of alternative construction materials and the development of technologies able to use low quality raw materials and produce high quality products (bark, low density, knotty wood, branches, etc.) More selective use of declining resources, more reuse and recycling Technologies to allow the current resource to go further – eg. thin veneering, wane-wood and hollow construction Lack of availability of some wood species will require technologies to duplicate the look/style of these
Wood substitutes Increasing competition in the building industry Increasing mixture of components used in building systems Low maintenance, easy care products	Technologies which allows combination of materials – and effective design guides, manuals, standards and fixing systems which are not material-dependent.
Building systems Zero waste manufacturing Pre-fabricated housing Standardisation of design, rapid construction techniques, modular systems. Use of wood products in intensive housing	Just-in-time manufacturing and assembly, with optimised cutting of lumber into componentry will aid zero waste manufacturing A smarter construction environment and growing dependence on IT systems and greater co-operation in construction industry to deliver innovative, cost effective solutions.

Table 1: Implications for the wood products industry

Although wood-based products generally have greater versatility in construction than other materials and are therefore well placed to cater for these future needs, the above table shows some challenges for the wood and construction industries.

A proportion of the radiata pine wood produced is not fit for purpose unless it is treated or further processed. Some preservative, adhesive and coating practices pose a risk to the environmental life cycle performance of the product, and threaten the popular image of radiata pine products as being environmentally friendly. As so much of our economy depends on our clean, green image, it is vitally important to substantiate excellence in environmental stewardship.

The marketing of non-wood, easy-care systems in intensified units has raised concerns about maintenance issues with wood products. If wood is to retain its dominance in new residential construction, wood-based technologies and guidelines for design codes and manuals to achieve efficient design in multi-storey housing developments are required. Wood frame and panel systems are relatively adaptable structures and will have advantages over more fixed structures such as concrete and steel. Multiple use and personalisation of interiors in the modular environment will again encourage demand for flexible systems, which favours wood.

The need to create more sustainable developments is being driven by environmental and energy markets, adherence to the Kyoto protocol and Agenda 21. It is anticipated that these will become mainstream within the next 2- 4 years, and while timber is a sustainable resource, lifestyle trends are changing the face of the urban environment, and presenting new challenges to the timber industry. Nevertheless, the mounting move towards sustainable building presents a large opportunity to New Zealand grown timber and through continued sustainable plantation management; low embodied energy, clean processing; integrated design and detailing; appropriate material selection for construction; and promotion about the contribution timber can make to sustainable development, it is well placed to meet this future challenge. The push towards sustainable building practice will only grow – the time is now for wood to seize these opportunities.

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Comprehensive Assessment System of Building Environmental Efficiency in Japan (CASBEE-J)

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1. INTRODUCTION

As the trend towards sustainable buildings becomes widespread, many environmental assessment systems for buildings have captured considerable attention worldwide; these include BREEAM (Building Research Establishment Environmental Assessment Method), LEED (Leadership in Energy and Environment Design), and GB Tool (Green Building Tool). To be nationally authorized in Japan, a governmental and academic project has been launched to establish a new system named the Comprehensive Assessment System of Building Environmental Efficiency (CASBEE-J).

2. FRAMEWORK FOR A NEW ENVIRONMENTAL ASSESSMENT OF BUILDING

2.1 A historical review of the environmental assessment of buildings

2.1.1 Stage 1 The oldest form of environmental assessment of buildings in Japan is the performance assessment of building environments, mainly indoor environments, which is basically aimed at improving living amenities or enhancing convenience for occupants. This can be thought of as Stage 1 in the evolution of the environmental assessment of buildings. At this stage, since the local environment surrounding the building concerned and the global environment were generally considered as open systems, environmental assessments paid no attention to the fact that buildings simply discharged their environmental loadings into their surroundings. In this sense, the philosophy behind environmental assessments was very clear, but opposite to today's approach.

2.1.2 Stage 2 The growth in public concern over air pollution problems in urban areas such as Tokyo in the 1960s led to the establishment of environmental impact assessment in developed societies. This was the time when environmental loadings started to be incorporated into building environmental assessments. This can be thought of as Stage 2. Here, only the negative effects that buildings have on their surrounding environments, such as urban pollution, are considered as environmental impacts, i.e. environmental load. In Stage 1, the environment mainly suggests a private space or property, whereas in Stage 2 it is a public space, although both Stage 1 and Stage 2 deal with the environment.

2.1.3 Stage 3 Stage 3 in the evolution of environmental assessments of buildings began after the rise in consciousness of global environmental problems in the 1990s. These systems

include BREEAM, LEED and GB Tool. The main issue in assessment at this stage is the negative impacts, in other words, the environmental loadings, the buildings have on the environment through their lifetime. In addition, building performance was also included as an object in some assessments, as in Stage 1. Notably, none of the assessment tools mentioned above clearly distinguish between these two basic assessment objects (in Stage 1 and Stage 2). Also, the scope (or the boundary) of the assessment objects is not clearly stated. In this sense, the concept of environmental assessment in Stage 3 lacks the clear underlying philosophy found in Stage 1 and Stage 2.

2.2 New stage in the environmental assessment of building: Stage 4

2.2.1 The boundary for assessing closed ecosystems and environmental capacity Stage 3 in environmental assessment began when it was recognized that the capacities of local environments, or the earth as a whole, were reaching a limit. As a result, the concept of closed ecosystems became essential for determining environmental capacities when conducting environmental assessments.

Therefore a hypothetical enclosed space bounded by the borders of the building site, as shown in Figure 1, is proposed here in making environmental assessments of buildings. This concept may be missing in Stage 3 assessments. The environmental loadings can thus be defined as "the negative environmental impact that extends outside to the public environment beyond the hypothetical enclosed space." The improvement of environmental performance within the hypothetical enclosed space is defined as "the improvement in the living amenities for building users." Dealing with both factors, Stage 4 environmental assessments clearly define these two factors, and distinguish between them as defined by BEE in Equation 1 of the following section. This makes the philosophy of assessment much clearer, and it has been used to form the framework of CASBEE-J.

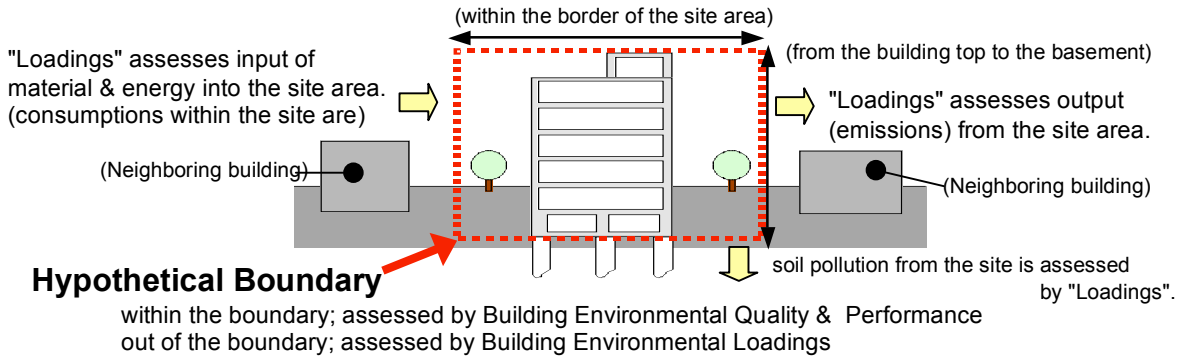


Figure 1 Hypothetical Boundary in Assessing Building Environmental Quality & Performance and Building Environmental Loadings

2.2.2 Definition of Building Environmental Efficiency (BEE) The definition of Building Environmental Efficiency (BEE) makes the concept of Stage 4 environmental assessments simpler and clearer. BEE is an indicator calculated according to equation 1 below.

$$\text{Building Environmental Efficiency (BEE)} = \frac{\text{Building Environmental Quality \& Performance}}{\text{Building Environmental Loadings}} \quad (1)$$

The numerator is Building Environmental Quality & Performance, which represents the condition of the living environment being assessed in terms of amenities for building users;

the denominator is Building Environmental Loadings. This idea refers to the eco-efficiency indicator that is normally defined as "values of products or service per environmental load unit." (Ministry of Environment of Japan, 2001)

3. ESTABLISHING A COMPREHENSIVE ASSESSMENT SYSTEM OF BUILDING ENVIRONMENTAL EFFICIENCY IN JAPAN (CASBEE-J)

3.1 Project outline: Stage 4 and CASBEE-J

Designated over three years, the project for developing CASBEE-J is currently being undertaken by the governmental administration concerned in collaboration with academic, industrial and public sectors. CASBEE is entirely based on the philosophy addressed in Stage 4 of environment assessment that the authors have elaborated in this project. A major objective in developing the system is to meet both the political requirements and market needs to achieve a sustainable society throughout building lifecycles. CASBEE-J comprises the following assessment tools:

a) *The Pre-design Assessment Tool* (Tool-0), which supports owners and planners in identifying the basic context of the project. This may suggest proper site selection and the primal impact of the project. (This tool is not covered in this three-year project)
b) *The DfE (Design for Environment) Tool* (Tool-1), which is a simple self-evaluation check system for designers and engineers to improve the BEE of relevant buildings during the design process
c) *The Eco-labeling Tool* (Tool-2), with which buildings are rated in terms of BEE after completion. This could be used to determine the basic property value of the labeled building in the market.
d) *The Sustainable Operation and Renovation Tool* (Tool-3), which provides building owners and managers with information concerning how to improve the BEE of their own building property during the post-design process

Each tool has its own purposes and target users. These tools are designed for use along with the building design processes, beginning with the Pre-design phase, and followed by the Design and Post-design phases. CASBEE-J covers the assessment of different types of buildings including offices, schools, and multi-unit residential buildings. Following extensive review of existing national and international assessment systems, CASBEE-J covers four assessment aspects, Energy Consumption, Cyclical Use of Resources, Local Environments, and Indoor Environments.

3.2 The DfE (Design for Environment) Tool

3.2.1 Design Framework for the DfE tool This paper explains *The DfE (Design for Environment) Tool* (Tool-1) designed as a simple self-evaluation check system for designers and engineers, as described above. The tool is planned for use in assessing buildings of any type or size. Assessments should be carried out at three design stages: the basic design stage, the design development stage, and the construction completion stage. To operate the system, the assessor fills out two assessment forms at each design stage: the Assessment Result Sheet and the Score Sheet shown in Figures 2 and 3. Figure 2 describes the basic structure of the forms for the DfE Tool, and a detailed illustration of the forms is shown in Figure 3, in which the Assessment Result Sheet is shown in front of the Score Sheet.

3.2.2 Assessment Result Sheet The Assessment Result Sheet mainly displays the result of the assessment of a building using CASBEE-J as shown in Figures 2 and 3. "(1) Project Outline" on the Assessment Result Sheet summarizes the main features of the building being assessed, such as its name, size, and structure.

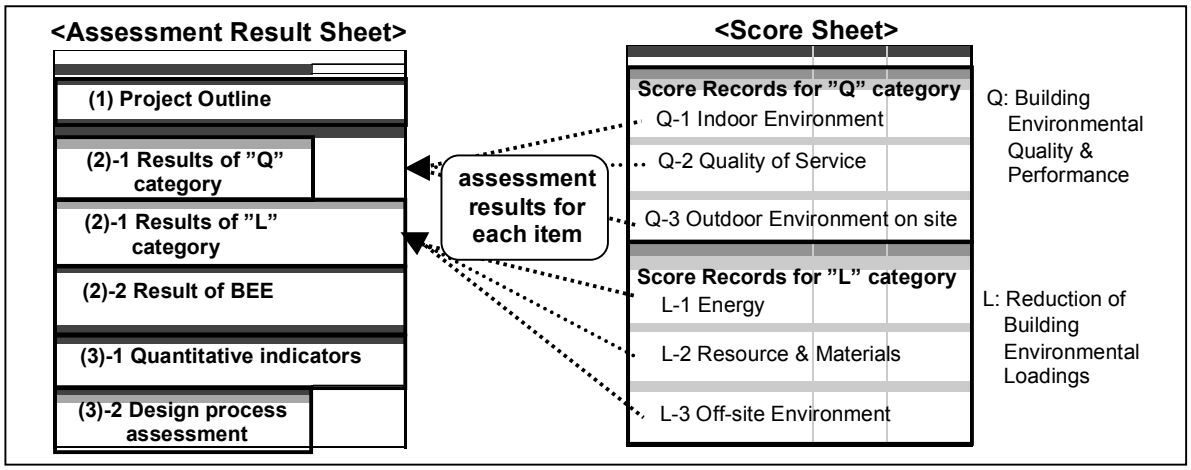
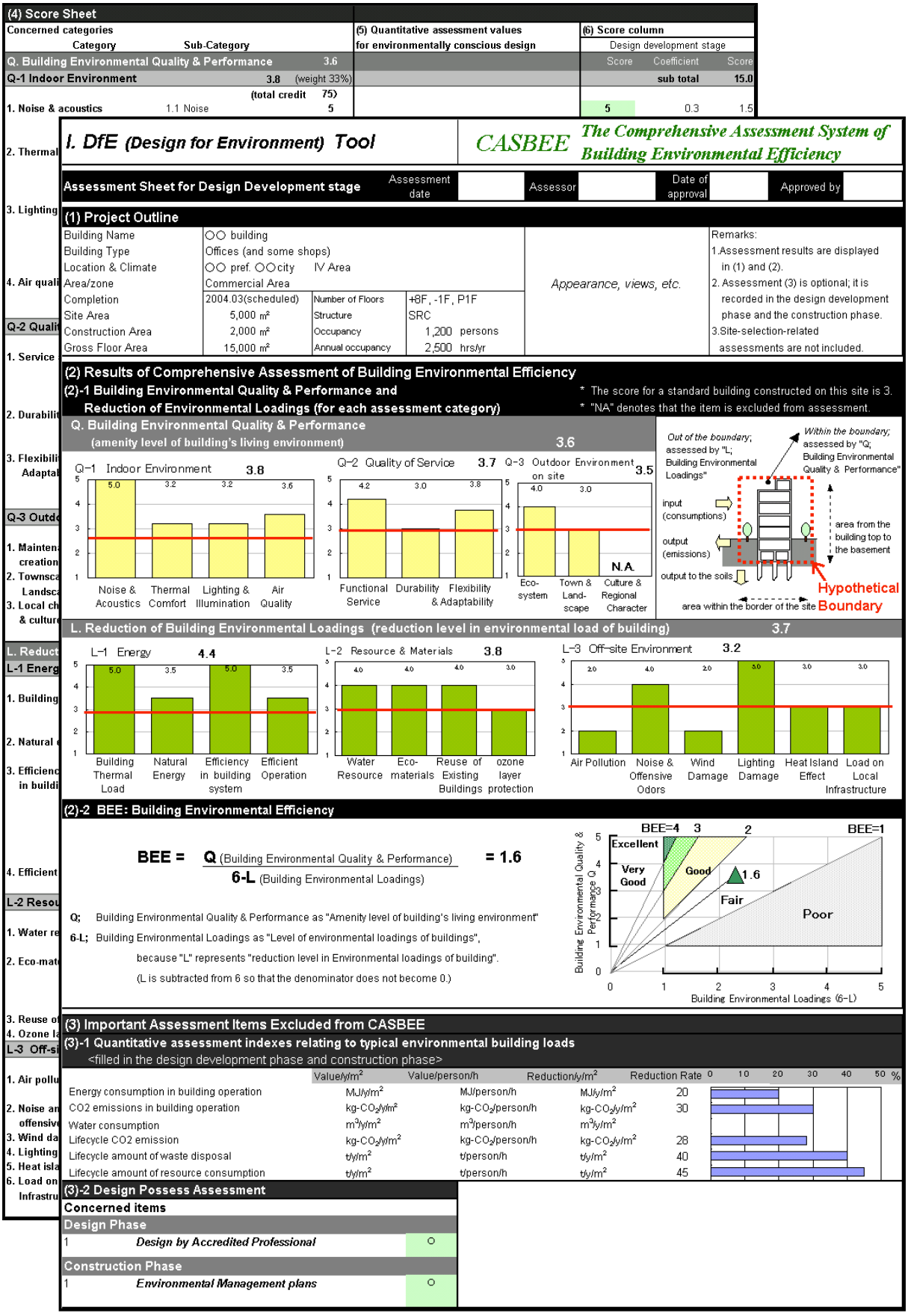


Figure 2 Basic Structure of the DfE Tool of CASBEE-J

Below "Section (1) (Project Outline)," (2)-1 and (2)-2 in Figures 2 and 3, graphically summarize the assessment results for each category given from the ratings for each item in the Score Sheet. They are displayed in the form of bar graphs and numerical values in (2)-1. The assessment results for the "Q; Building Environmental Quality & Performance" category are displayed in the upper panel, while the results for the "L; Reduction of Building Environmental Loadings" category are shown in the lower panel. Here the indicator L represents not the building environmental load itself, but the level of performance in minimizing building environmental loadings imposed outside the hypothetical boundary. The better a building performs in reducing the environmental load, the higher the score it receives for this indicator L. Furthermore, the assessment results for Q are broken down into the categories of "Q-1 Indoor Environment," "Q-2 Quality of Service," and "Q-3 Outdoor Environment on Site." Similarly, the assessment results for L are categorized into "L-1 Energy," "L-2 Resources & Materials," and "L-3 Off-site Environment." Section (2)-2 displays information on BEE, as calculated from the results for Q and L. The left side of the panel shows the value of BEE as shown in Figure 3. On the right side there is a graph of Q against (6-L), where the gradients of the lines represent the BEE values. This visually shows the relative environmental sustainability of the assessed building. Details of this section and BEE are described in the following chapter.

Section (3) in Figures 2 and 3 presents optional assessment items. (3)-1 shows the Quantitative Values of indicators that are not included as part of the comprehensive assessment (2), but which are still useful for the environmental assessment of the building. These indicators may include the amount of primary energy consumption, the water consumption in operation, and LCCO2 emissions. Design Process Assessment (3)-2 assesses important environmental consideration items relating to the environmental management of the building.

3.2.3 Score Sheet The assessment results for each assessment item are given as scores on the Score Sheet. The sheet is divided into sections representing the various categories of assessment. Scores are given based on the scoring criteria for each assessment item. These criteria applied to assessments are determined in consideration of the level of technical and social standards at the time of assessment. A five-level scoring system is used, and a score of level 3 (i.e. three points) indicates an "average" assessment. The scores for each assessment item are multiplied by a weighting coefficient, and aggregated into the sub-total scores for sub-categories. Total scores can then be calculated for each category.



(front; Assessment Result Sheet, back; Score Sheet)

Figure 3 Details of *The DfE (Design for Environment) Tool*
(Draft sample for design development stage assessment)

4. CONCEPT OF BEE (BUILDING ENVIRONMENTAL EFFICIENCY)

In CASBEE-J, the assessment scale for Q and L is from 1 to 5. The building environmental loadings can be given by (6-L), where L represents the level of reduction of the building environmental loadings. Equation 1 can then be expressed by the following formula.

$$BEE = Q / (6-L) \quad (2)$$

The reason for using 6 is to avoid making the denominator zero. If Q is plotted on the vertical axis against (6-L) on the horizontal axis, the assessment results can be displayed on a graph, as shown in Figure 4 below. BEE values, calculated using Equation 2, are represented on the graph by the gradients of the lines connecting the assessment results and the origin (0,0). The triangular symbol on the graph shows an example. The higher the value of Q and the lower the value of (6-L), the larger the gradient, which means that the building is more sustainable. In contrast, the smaller the gradient, the less sustainable the building. In this approach, it becomes possible to graphically present the results of building environmental assessments using areas bounded by these gradients (environmental labeling). Figure 4 shows how the assessment results for buildings can be labeled on a diagram as Poor, Fair, Good, Very Good, and Excellent, in order of increasing BEE values. To make this approach more reliable, it is desirable that the methodology to determine Q and L values is continuously revised through the accumulation of assessment results. For further investigation, such revision may consider a quantitative approach to assessments; for instance, using the LCA process on buildings to give the L value.

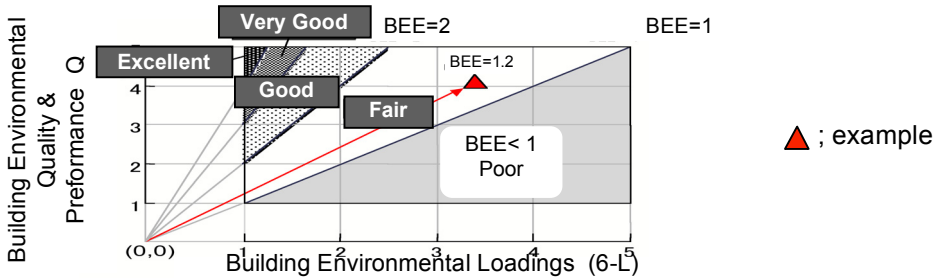


Figure 4 Graphical expression of Environmental Labeling based on BEE

5. CONCLUSIONS

- The concept of CASBEE-J is presented following the concept of Stage 4, based on a historical review of the environmental assessment of buildings.
- A concept of hypothetical boundary for the building site is proposed in establishing CASBEE-J, and this is used to define assessment categories Q (Building Environmental Quality & Performance) and L (Reduction of Building Environmental Loadings).
- BEE (Building Environmental Efficiency) is proposed for expressing the assessment result clearly by CASBEE-J in a simple form.
- CASBEE-J comprises a variety of assessment tools designed along with the building design processes. Details of the DfE Tool are presented.
- A graphical expression based on BEE suggests that BEE can be applied to the environmental labeling of a building.

6. ACKNOWLEDGEMENTS

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Sustainable Building Material Products from Bio-fibre Raw Materials

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1. INTRODUCTION

In 1999 CIB (International Council for Building and Construction) in cooperation with some other organisations published the document "Agenda 21 on Sustainable Construction". In this document it is stated that "The construction industry and the built environment must be counted as two of the key areas if we are to attain a sustainable development in our societies."

The construction sector has a great impact on the environment because buildings are responsible for more than 40 % of the total energy consumption and almost 40 % of all carbon dioxide is produced in buildings. Besides the construction sector is estimated to generate approximately 40 % of all man-made wastes.

Thus the world community is facing a challenge in having to decrease pollution levels, while at the same time significantly increasing industrial output. Such predictions have led to support for enhanced industrial use of renewable resources at the expense of non-renewable resources. Bio-fibres may therefore face a renaissance, not only for old industrial products but also for the manufacture of new types of materials and products.

Industrial use of bio-fibres as wood fibres for the manufacture of pulp, paper, fibreboards and particleboards are well established in the world. The renewed interest in industrial use of bio-fibre based materials within the automotive, building, furniture and packaging industries has led to development and production of many new bio-fibre based products.

Several companies in the building material industry worldwide are interested to produce products based on bio-fibre raw materials. It can be products for outdoor decking as roof plates, wall boards, windows and door panels. Most of the fibres that are used come from short wood fibres but some parts come from long jute-, flax- and hemp fibres.

2. BIO-FIBRE RAW MATERIALS

2.1 Bio-fibre production

The annual global production of bio-fibre raw materials are today about 4 billion tons of which roughly 60 % come from agricultural crops and 40 % from forests. In comparison, annual world production of steel is currently around 0,7 billion tons and plastic production is around 0,1 billion tons. As an example the Swedish annual production of bio-fibres is about 50 million tons from forestry and about 0, 1 million tons from agriculture.

Bio-fibres are subdivided based on their origins. They are coming from leafs (abaca, sisal, henequen), seed-hairs (coir, cotton), basts (flax, hemp, jute, ramie) and wood. Most of the

plant fibres, which have an European interest are coming from flax and industrial hemp. These varieties are cultivated for both their fibres and their oil. Both flax and indusrial hemp are annual plants. Flax grows up to 1 m high and produce about 1 ton bast fibres per ha. Industrial hemp may grow up to 4 m high and produce about 3-4 ton fibres per ha.

In table 1 the worldwide production of plant fibres in 1999 divided into fibres and main country producer is shown. This plant fibre production amount is focused on the main fibre plants and does not include straw and wood fibre production.

Table 1 Worldwide production of Plant Fibres in 1999 (Karus, 2000).

Fibre	Main country producer	Production in million tons	Production in % of total
Cotton	China, USA, India, Pakistan	18.20	78.5
Jute	India, China, Bangladesh	3.37	14.5
Flax	EU, China, Eastern Europe	0.63	2.7
Sisal	Brazil, China, Mexico, Kenya	0.38	1.6
Cocos	Indien, Sri Lanka	0,27	1.2
Ramie/Abaca	China, Ecuador, Philippines	0.27	1.2
Hemp	EU, China, Eastern Europe	0.07	0.3
Total		23.19	100



Figure 1 Short fibres from oak, wheat and beech in the front and long fibres from coco, flax and sisal in the back (left to right) (Olesen, 2001).

2.2 Bio-fibre structure and properties

All plant species are made of cells. When a cell is very long in relation to its width it is called a fibre. The fibre is like a microscopic tube and it consists of cellulose, hemicelluloses and lignin. Cellulose is the basic structural component of all plant fibres. The cellulose molecules consist of glucose units linked together in long chains. Hemicelluloses are also found in all plants. Hemicelluloses are polysaccharides bonded together in branching chains. Lignin is the compound, which gives rigidity to the plant. Lignin is a three-dimensional polymer with an amorphous structure (Olesen & Plackett, 1999). Pectin is the glue, that holds the fibre bundles together. In table 2 the chemical composition of some selected agricultural and wood fibres is shown.

Table 2 Chemical composition of some selected agricultural and wood fibres (weight-%) (Olesen & Plackett, 1999).

Fibre	Cellulose	Hemi-Cellulose	Lignin	Pectin
Jute	70-75	12-15	10-15	1
Flax, hemp	68-85	10-17	3-5	5-10
Seed hair, cotton	89-99	3-6	-	-
Wood	38-45	24-39	22-34	0.5

The good specific mechanical properties are due to their relative high strength and low density. In table 3 mechanical properties of plant fibres are compared with conventional reinforcing fibres.

Table 3 Mechanical properties of plant fibres as compared to conventional reinforcing fibres (Biedzki & Gassan, 1999).

Fibre	Density (g/cm3)	Elongation (%)	Tensile strength (MPa)	Young´s modulus (GPa)
Jute	1.4	1.5-1.8	200-450	20-55
Flax	1.5	2.7-3.2	500-900	50-70
Hemp	1.5	1.6-3.5	310-750	30-60
Sisal	1.5	2.0-2.5	80-840	9-22
E-glass	2.5	2.5	2500-3500	70-73
Aramid	1.4	3.3-3.7	3500-4000	85-135
Carbon	1.4	1.4-1.8	2500-6000	220-700

The combined effect of the three main constituents results in properties, which are unique for plant fibres. The most important properties are:

* High tensile strength and low density. In relation to its weight the best bast fibre attain strength properties similar to that of fibre-glass.
* High heat, sound and electrical insulating ability
* Biodegradability

3. BUILDING MATERIAL PRODUCTS

3.1 Mats

A number of bio based products are made from mats, which are made of bio-fibres or a mixture of bio-fibres, plastic fibres and resins in varying amounts. Mats may be used in a number of products, e.g. filters for air and water, growth media for production of vegetables, flowers and grass mats. Bio-fibre geo textiles are already available on the market. Bio-fibre mats also have a promising future as insulation material within the building industry. The market potential for partial replacement of mineral wool mats for insulation is huge.

Insulation materials made of flax and hemp fibres show advantages, which make these products excellent construction materials. They are clean to process and produce very little dust. They can be tolerated very well by the skin, it does not cause any itching.

”Thermo-Hemp” is a German example of a hemp fibre insulation product, which is composed of 85% hemp fibres and 15% polyester carrier fibres. Soda is added as fire - proofing. “Thermo-hemp“ is the world’s first hemp insulation, which has been approved for use in construction. That was issued by the German Institute for Constructional Engineering in Berlin. Hemp felts have the property to absorb moisture from the surrounding air and to emit this moisture again as soon as the air has dried. The result is a better indoor climate. “Thermo-hemp“ has good thermal insulation properties and is delivered in the form of mats. It is suitable for insulation in roofs, walls or floors. It makes no difference whether it is used for new or old buildings.

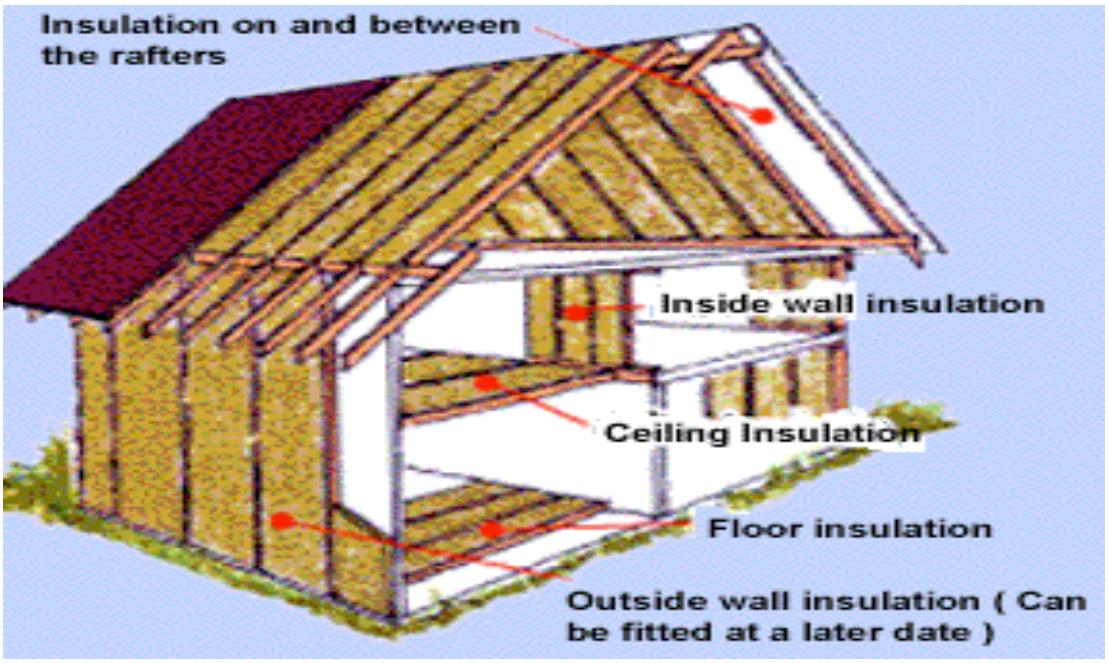

Figure 2 “Thermo-hemp“ is suitable for insulation in roofs, walls or floors (Hock homepage, www.thermo-hanf.de)

Another example of a bio-fibre insulation product is “Zapp”, which is a new Swedish product. The product contains 80% cellulose fibres and an inorganic binder based on stable silicate compounds. The insulation mat is biodegradable and can be recovered to new products. When the product is deposited it will moulder to organic material. “Zapp“ has good insulation properties and is delivered in the form of mats. It is suitable for insulation in roofs and walls.

3.2 Composite Products

Composites for structural and non-structural purposes are manufactured by hot pressing of mats. Fibre/polymer composites can also be manufactured through extrusion or injection moulding. New fibre/cement composites can be designed to have the required stiffness and strength. The importance of the role of final product design can not be overstated.

Plant fibre reinforced thermoplastic composites for the building industry may be products with climatic protective functions and less load-bearing capacity. The composites are manufactured by different technologies e.g. extrusion, injection moulding, thermoforming, vacuum forming and resin transfer moulding. The thermoplastic compounds are usually environmental friendly e.g. polypropylene, polystyrene, vinyl and high- and low-density polyethylene.

Product examples for the building industry are window frames, door panels and wall panels. Window frames made of plant fibre reinforced thermoplastic should be competitive to corresponding product reinforced with fibre-glass.

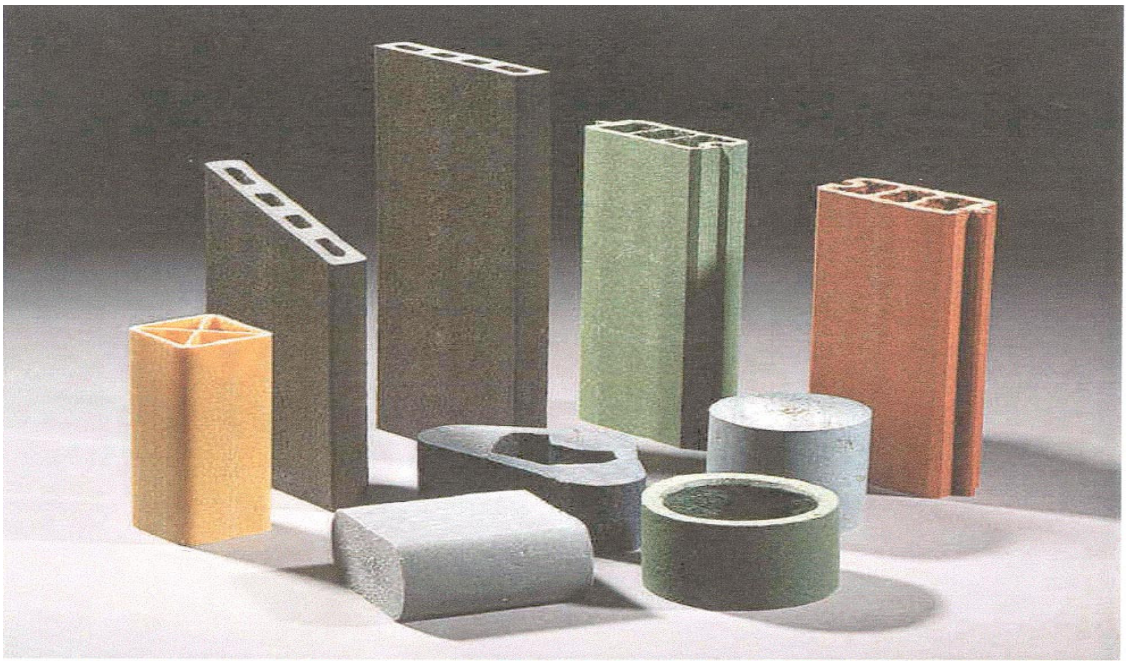

Figure 3 Plant fibre reinforced thermoplastic composites (Olesen, 2001).

Roofing is one of the most important and difficult problem in housing. In most developing countries and in many industrialized countries natural materials are used for roofing in rural areas. An interesting solution to the roofing problem seems to be thin sheets made of plant fibre concrete.

When mixing plant fibres in the mortar the fresh concrete may be shaped in a simple manner, which is one advantage with this material technology. Another advantage is that the fibres increase the toughness and impact resistance of the hardened concrete. This means that the material may be used in structural applications. A corrugated roof sheet is probably one of the most interesting forms even if other forms can be produced. Apart from roofing materials plant fibre concrete can be used for production of sun screens, thin-walled blocks, small beams, and other products.

4. DISCUSSION

Today we see a fast development in the industrialized world, primarily in USA and Europe, towards utilization of bio-fibres as an industrial raw material. This change from synthetic oil based plastics towards environmental friendly (renewable and recyclable/compostable) materials, is of great importance in order to eliminate an ecological crisis.

Examples of bio-fibres from Nordic agriculture and forestry are flax and hemp fibres and pine and spruce fibres. The use of bio-fibres in industrial products is CO_2 neutral. The use of bio-fibres is also very price competitive to synthetic fibres as fibre-glass. The bio-fibre based products show renewability and biodegradability.

The most beneficial advantage is the high specific strength and stiffness. This advantage concerns mostly the long fibres from flax and hemp. These fibres show a low density and a relatively high tensile strength. These properties make together the bio-fibres very competitive compared to fibre-glass.

There are also disadvantages of bio-fibre utilization. One disadvantage is the variability of the fibre dimensions. The length and the diameter of the bio-fibres vary very much in production. This is natural because we deal with biological material but the problem has to be solved in the production process.

5. CONCLUSIONS

There is an abundance of biological fibres in the world, both from agriculture and forestry and there are many advantages of bio-fibre utilization. The greatest advantage is the high specific strength and stiffness. This advantage concerns mostly the long fibres from jute, flax and hemp.

The goal for the bio-fibre building material product development should be to present for the market completely "green" products based only on biological raw materials. This is a challenge for research institutes and industry, which includes solving the main problems.

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The use of recycled concrete aggregates in the Norwegian building and construction industry

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1. INTRODUCTION

Though the reduction of construction and demolition waste (C&D-waste) through recycling and reuse has received increased attention in the recent years, it is still not standard practice in Norway. However, changes in the Norwegian building and construction industry in the last 4-5 years towards more recycling and reuse, utilizing the C&D-waste for new construction, follows the trend seen in many countries around the world.

Lack of reliable C&D-waste statistics with respect to both the amount of waste generated on an annual basis in each region and the split between the various waste fractions, makes it difficult to measure the current level of C&D-waste recycling in Norway. Annual C&D-waste production in Norway, however, is approximately 1,5 mill. tons per year with about 70 % (1,1 mill. tons per year) consisting of concrete and masonry rubble (Statistics Norway, 1999). This is low compared to most EU countries, Mehus et. al. (2000). Rough estimates indicate current levels of recycling and reuse in Norway to be 10-20 %.

This is significantly less than countries like The Netherlands and Denmark. Then again, Norway hasn't had quite the same motivation as other countries. Norway is scarcely populated with only 4,5 mill. inhabitants spread out over large areas. At the same time, there is extensive access to primary raw materials, such as large natural aggregate reservoirs. On the other hand, reduced consumption of primary raw materials controlled handling of hazardous waste, and less waste landfilled are important objectives for the Norwegian authorities as well. The Norwegian building and construction industry recently published a national action plan for C&D-waste setting several ambitious objectives, BNL (2001). Specifically with respect to recycling, the industry's target is that by 2005 no more than 30 % of the C&D-waste should be landfilled annually.

In 1998, approximately 10 years after European countries like The Netherlands and Denmark lead the way, the first commercial recycling facility opened in Oslo. BA Gjenvinning, a produce and sell recycled concrete aggregate (RCA) from heavy C&D-waste (concrete and masonry rubble). However, lack of sufficient technical documentation and reference projects soon proved to be yet another obstacle to the use of RCA in Norway.

2. RESIBA

2.1 Objective and organization

The Norwegian research and development project RESIBA – Recycled Aggregates for Construction and Building (1999-2002) aimed at making RCA a competitive product for various applications within the Norwegian building and construction industry. The main objective of RESIBA was to encourage long-term use of RCA by:

- Disseminating new knowledge and results obtained in the RESIBA-project through systematic documentation and demonstration projects using RCA.
- Actively applying existing knowledge and experience on recycled building materials from other various projects both nationally and internationally.

EcoBuild, a five-year development program initiated by the Norwegian building and construction industry to increase the environmental efficiency of the industry, funded the RESIBA-project together with the project partners. The RESIBA-project included key representatives from the customer base, the producers, the public sector, and the research sector. The partners were Veidekke ASA (contractor), Norwegian Building Research Institute, BA Gjenvinning AS, Norwegian Public Road Authorities, Kontrollrådet for Betongprodukter (Norwegian certification organization), City of Oslo, Akershus County Municipality and Optiroc AS (building block manufacturer).

2.2 Work packages

The project was divided into three work packages:

- **Work package 1: Declaration and quality control**
  The aim was to produce a proposed system with parameters and routines for the quality control of RCA. This required extensive testing of important material properties and environmental leaching characteristics of RCA in order to document the main properties and possible environmental influences of the product
- **Work package 2: Demonstration projects**
  The aim was to evaluate the use of RCA in already completed construction projects and to launch various demonstration projects investigating the use of RCA in roads, trenches and different types of concrete structures.
- **Work package 3: Dissemination of results**
  The aim was to make knowledge and experience from the project widely available through a project web site, technical reports, articles, papers, seminars, courses etc.

3. DEMONSTRATION PROJECTS

3.1 Unbound use of recycled aggregates

A wide range of demonstration projects was initiated using RCA for various bound and unbound applications. As has been seen in countries like The Netherlands and Denmark unbound application in road and highway construction is expected to be the most common and profitable. For unbound applications of RCA the demonstration projects initiated were:

3.1.1 Roads and parking lots

In August 2000 the Oslo Public Roads Administration opened a new motorway through the Svartdal tunnel. A 50 m test section was established outside of the tunnel using approximately 600 tons of RCA 20-120 mm as sub-base. The thickness of the sub-base layer was approximately 0,9 m. In addition, a 50 m reference section was established using natural

aggregates in the sub-base layer. Plate loading tests were performed, measuring the modulus of elasticity of the two test sections. In addition, the two test sections are currently being monitored measuring rut depth and the longitudinal evenness of the road surface.

Oslo Sporveier's new tramline over Gaustadbekkdalen in Oslo, completed in 1999, included the use of approximately 4000 m^3 of RCA as base material on top of a lightweight filling, and as backfill behind retaining walls. The project has been monitored by RESIBA, measuring deformation of the RCA base layer.

RCA has also been successfully used in 1996 as a base layer at a bus parking at Klemetsrud in Oslo, as backfill in drainage trenches at Skullerud in Oslo in 1997 and in pedestrian/cycle paths in Oslo. All projects are presented by Myhre et. al. (2002).

3.1.2 Trenches and backfills

Full scale laboratory testing conducted by the Norwegian Building Research Institute (NBI) indicated that RCA would function well as backfill materials in the pipe zone in utility trenches. The testing included various full-scale test set-ups exposing RCA to mechanical loading (simulating traffic load) and high volume water drainage.

In a demonstration project, Asker municipality used about 1000 tons of RCA (10-20 mm) as backfill in a 600 m utility trench for water and gas drainage from a landfill, Mehus et al. (2002) and Ingebriktsvold, Mehus (2000). The project has been closely monitored measuring deformation at various levels and locations along the trench.





Figure 1 Left: RCA as sub-base in the Svartdal tunnel in Oslo.
Right: Landfill in Asker using RCA as backfill in a 600 m utility trench.

3.2 Bound use of recycled aggregates

3.2.1 Concrete

During the construction of a new parking garage at Fornebu outside Oslo, the contractor, Veidekke ASA, incorporated the use of RCA by replacing 20 % of the coarse aggregate in the concrete foundations, Lahus et. al. (2002a and 2002b). Concrete production and casting of the foundations were successful, and the laboratory test results show that the concrete met the material properties as specified. Laboratory testing of concrete using up to 100 % RCA has also yielded positive results.

3.2.2 Shotcrete

One of the world's first employments of shotcrete incorporating RCA can be found at Oslo Sporveier's new tramline over Gaustadbekkdalen in Oslo, completed in 1999, Farstad, Hauck (2001), Hauck, Farstad (2001), Lahus et al. (2002a). The vertical sides of an EPS lightweight filling is protected by 100 m^3 of shotcrete in witch to 20 % of the sand was replaced by RCA. The contractor, Veidekke, successfully conducted the spraying, and the shotcrete met the material properties as specified. Testing included the determination of fresh shotcrete properties, mechanical properties, and durability characteristics.

3.2.3 Building blocks

Optiroc AS has produced Leca masonry sound insulation blocks using 30 % RCA, 4-10 mm. Laboratory testing demonstrate that all specifications for the Leca masonry sound insulation blocks are met, Lahus et al. (2002a).



Figure 2 Left: Concrete with RCA in foundations at Fornebu, Oslo.
Middel: Shotcrete with RCA in Gaustadbekkdalen, Oslo.
Right: Leca's building blocks with 30 % RCA.

In order to bring together the applications and to use RCA on a larger scale, at the conclusion of the RESIBA-project, RCA was included in both unbound and bound applications building a new high school in Sørumsand.

4. NEW HIGH SCHOOL IN SØRUMSAND

4.1 Project description

The new high school currently being built by Akershus County Municipality in Sørumsand just outside the city of Oslo was selected as the final demonstration project initiated by RESIBA. The new school building will be approximately 13 000 m^2. Construction started the summer of 2001, and the school will be ready for use by students during the fall of 2003. The high school building incorporates the use of RCA for unbound and bound applications, utilizing the results obtained through laboratory and field-testing in the RESIBA-project.

The use of RCA in the new building has been carried out in close cooperation with the design engineer, the contractor, the RCA supplier, and the concrete ready mix plant. The decision was made to include the use of RCA at an early stage, which allowed for recycled aggregates to be included as the main alternative in the bidding documents for the contractor.

4.2 Use of RCA

For the cast in place concrete (C35), in the foundations and in half the basement walls and columns, 35 % of the coarse aggregate was replaced with 10-20 mm RCA. A total of 800 m^3 concrete with RCA was used. The remainder of the basement was cast using 100 % natural

aggregates. Extensive testing of the aggregates properties, the fresh concrete properties and the hardened concrete properties was conducted. To avoid the risk of any future complications, concrete with RCA was not used for sections of the structure expected to be exposed to freeze-thaw action. Test results later showed, however, that the concrete with 35 % coarse RCA had excellent freeze-thaw resistance, Mehus, Hauck (2002), Lahus et al. (2002a). Hardened concrete properties were comparable, and concrete production and casting was conducted without any problems. Visually, the concrete with 35 % RCA looks just as even colored as the concrete with 100 % natural aggregates. The use of 35 % RCA did not cause any noticeable increase in cracking.

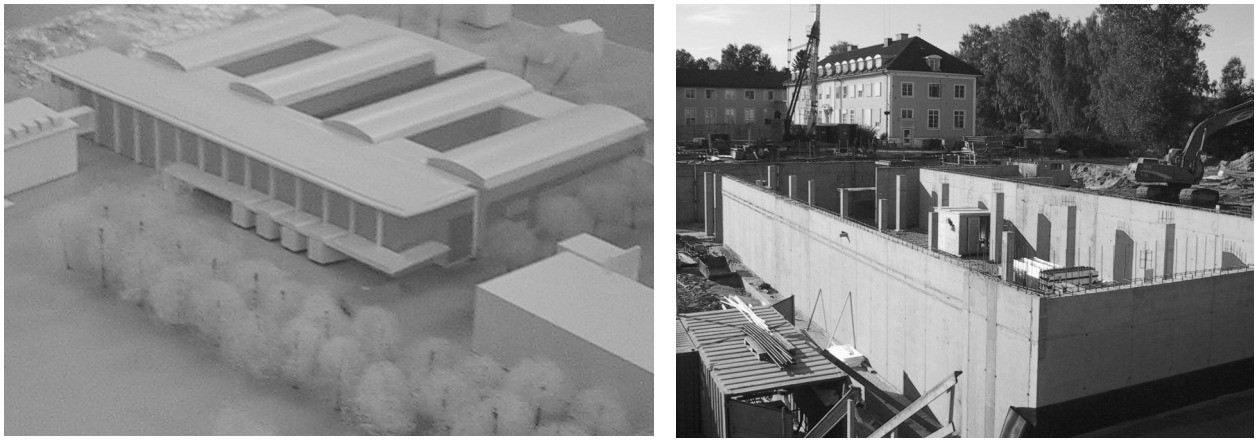

Figure 3 Left: Model of new high school building at Sørumsand
Right: Concrete walls and columns with 35 % coarse RCA.

In addition, large volumes of RCA were used as a sub-base between foundations and as a backfill against basement walls. Sound-insulation building blocks with 30 % RCA will also be used, and RCA will replace be used as road-base and sub-base in parking lots.

5. RESULTS

The RESIBA-project has successfully documented that RCA is a viable alternative to natural aggregates for a wide range of applications. As in most other countries, unbound applications such as road and utility trenches are expected to be the most important areas of use.

In general, the technical results from the various laboratory and demonstration projects using RCA are overall positive. Material properties such as mechanical strength, density, and water absorption are significantly different compared to natural aggregates. However, important functional characteristics such as deformation stability, load distribution, permeability, etc. are similar to those of natural aggregates. Laboratory testing of concrete replacing up to 100 % of the coarse aggregate with RCA also yielded positive results. Concrete with as much as 35 % of the coarse aggregate replaced by RCA was successfully used in regular construction at Sørumsand High School. None of the structures used as demonstration projects have suffered any kind of deterioration or damage due to the use of RCA as an alternative to natural aggregates. Also, the results reported by Engelsen et. al. (2002a and 2002b) with respect to potential leaching of harmful substances, showed that the RCA tested had no significant environmental impact.

The RESIBA-project has clearly documented a need for a system of quality control and declaration, such as, for example, the certification scheme proposed by the RESIBA presented by Karlsen et. al. (2002a and 2002b).

For most of the demonstration projects, the use of RCA ended up reducing the costs compared to natural aggregates. This is, of course, due to the lower cost per m^3 of RCA compared to natural aggregates (about 50 %). Transportation is crucial, however, and will be the deciding factor for the majority of projects. The availability of RCA and the ability to guarantee a steady supply to the construction site will also be important. Handling and construction using RCA did not cause additional labor or any other special problems on the construction site.

6. GUIDELINES FOR THE USE OF RECYCLED AGGREGATES

The RESIBA-project had put a strong emphasis on the dissemination of results. A variety of papers, articles have been published and detailed technical results are presented and discussed in depth in a series of seven project reports. In addition, a summary of the results and recommendations from RESIBA is presented in a 20-page booklet titled Guidelines for the use of RCA. The guidelines are not intended to provide detailed design specifications for consultants, but rather give a general orientation with easily accessible information about the most important areas of use for RCA in the Norwegian construction industry. The guidelines are available for download from the RESIBA website (www.byggforsk.no/prosjekter/RESIBA). The overall purpose of the guidelines is to increase the general level of knowledge of RCA as a viable alternative to natural aggregates for a wide range of applications, subsequently, increasing the use of RCA. The guidelines provide a two page overview of each of the following areas of use: Roads and parking lots, utility trenches, backfill an sub-base, concrete, shotcrete, building blocks.

These overviews also include references to and pictures from relevant demonstration projects, and references to technical reports published by the RESIBA project for more in depth technical information. The booklet includes a brief summary of the results with respect to potential problems with leaching of harmful substances. RESIBA's proposed system for declaration of RCA is also presented.

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Decision Analysis Support in Sustainable Building Projects

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1. INTRODUCTION

This paper describes experiences from using a formal method and tool to support decision-making in sustainable building. The Web-HIPRE tool (Mustajoki & Hämäläinen, 2000) was used for that purpose. It provides various means to weight elements of a hierarchical structure, and to compare their interrelated superiority based on how they meet the applied criteria with given weights. The tool can be used for visualising topics and their implications in teamwork sessions, and for documenting the wisdom behind decisions. It is very useful in cases where judgements on scientific basis are ambiguous or impossible, like "Is the health of human beings in buildings more important than depletion of natural resources for the mankind?" The same tool was tested also for comparing different technical solutions with a chosen subjectively weighted set of criteria - even if the scientific validity of the studied system model remained loose.

Two case studies are presented. The first one describes findings from a three-hour session where weights were defined for the Finnish Environmental Assessment System for Buildings (PromisE). The second one describes experiences from comparing three alternative building solutions from a large ICT firm's perspective, where environmental aspect was one issue among others.

2. DEFINING WEIGHTS IN ENVIRONMENTAL ASSESSMENT OF BUILDINGS

The Finnish Environmental Assessment and Classification System of Buildings (PromisE) is a tool for actors in the property, construction and building services industry (Rakli). The PromisE system is developed as a result of the Government decision (in December 1998) concerning the promotion of sustainable construction in Finland. It is still under a development and testing phase. Its contents (data gathering, indicators and assessment) have been tested in six buildings. The PromisE Internet tool will be published during summer 2002.

The PromisE system consists of four main categories: Human health, Natural resources, Emissions and Environmental risks. Those main categories are divided into sub categories with a defined content, input data and assessment methods. The management group of the development project had defined preliminary weights for different categories of the system before the weighting system was revisited with a group of experts in a half-day session in December 2001.

2.1 Weighting the system in a teamwork session

Weighting of the PromisE system was carried out in a seminar, in which 60 invited sustainable building experts of different backgrounds attended. Definition of a sustainable building expert means here that the participants were either building practitioners or representatives of organisations, who are involved in sustainable building projects. They were

building professionals who are supposed to know well what sustainable building means, especially in the Finnish context and from the environmental point of view.

The seminar was started with a presentation of the PromisE structure and contents. Then the participants were assembled into four pre-defined sectoral groups: one of them had the role of representing the building owners, the other designers (architects and engineers), third production (manufacturing and construction) and the fourth one building users. Each group had a facilitator, who knew well the PromisE system, and a machinist who operated the Web-HIPRE tool, keeping track on active discussion in the groups. The results were projected to screens in each group so that the participants could follow the process online.

The seminar was concluded in a plenary discussion where the four groups presented their results. The differences were argued and discussed, but there was no intention to achieve consensus within weights in that event. Four different weighting systems were later delivered to the management board as an outcome of that exercise.

The process in teams progressed using the bottom up approach. The lowest level issues were first explained, discussed, weighted, discussed again and agreed on. Figure 1 shows the importance of different health related issues as estimated in one group. Figure 2 shows how transport issues were first weighted, and then judged as part of the emissions category. Figures 1 and 2 together show the structure of the PromisE system.

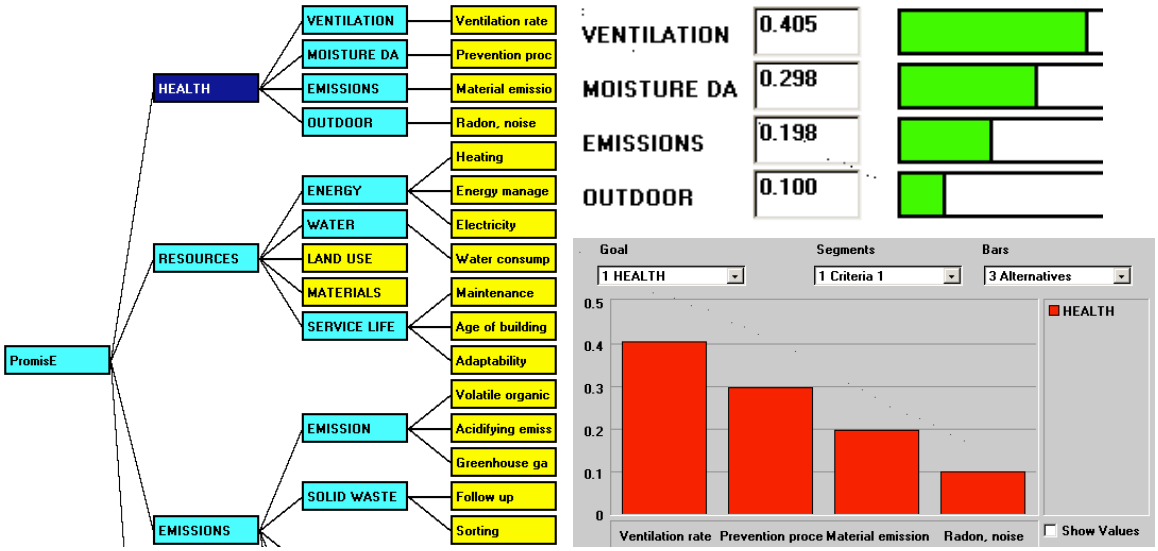

Figure 1 The top part of the PromisE system and weights within Health criteria.

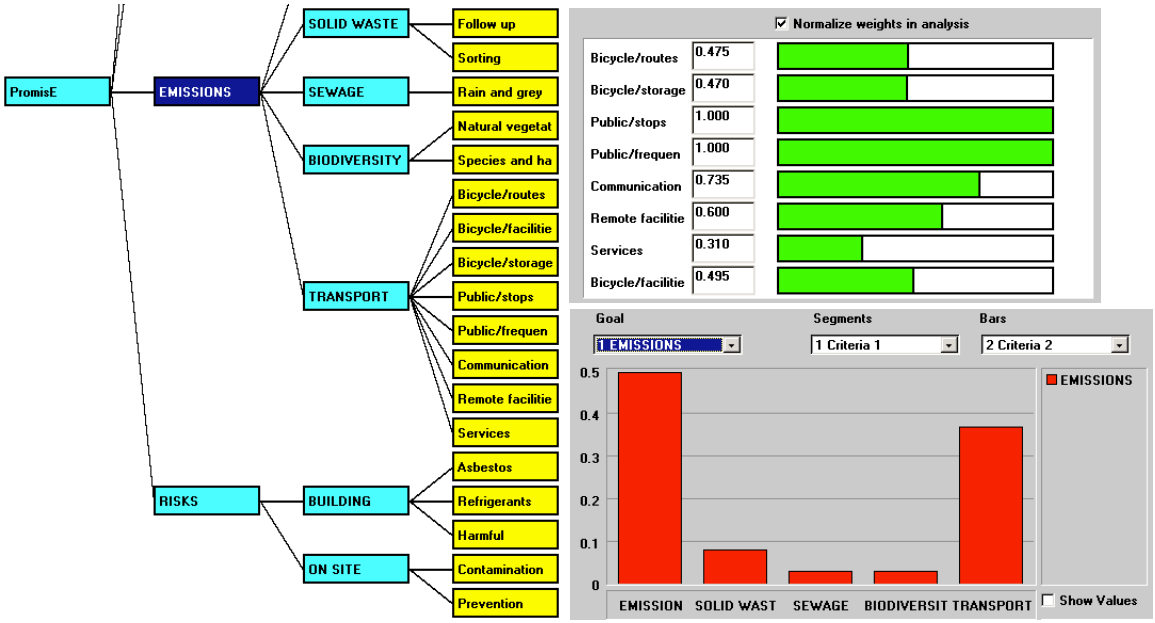

Figure 2 The lower part of the PromisE system and weights within Emission criteria, and within Transport issues as part of it

The weights were finally discussed at the highest level, when it was certain that the participant knew well what they were voting for. In other words: they were not expressing their general feelings or interpreting what they believed to be common environmental priorities. They judged the elements that were part of the PromisE system, and kept in mind their practical experience and their sectoral role in this case. The high level weights as shown in Figure 3 were defined using the Analytical hierarchy process (AHP) method.

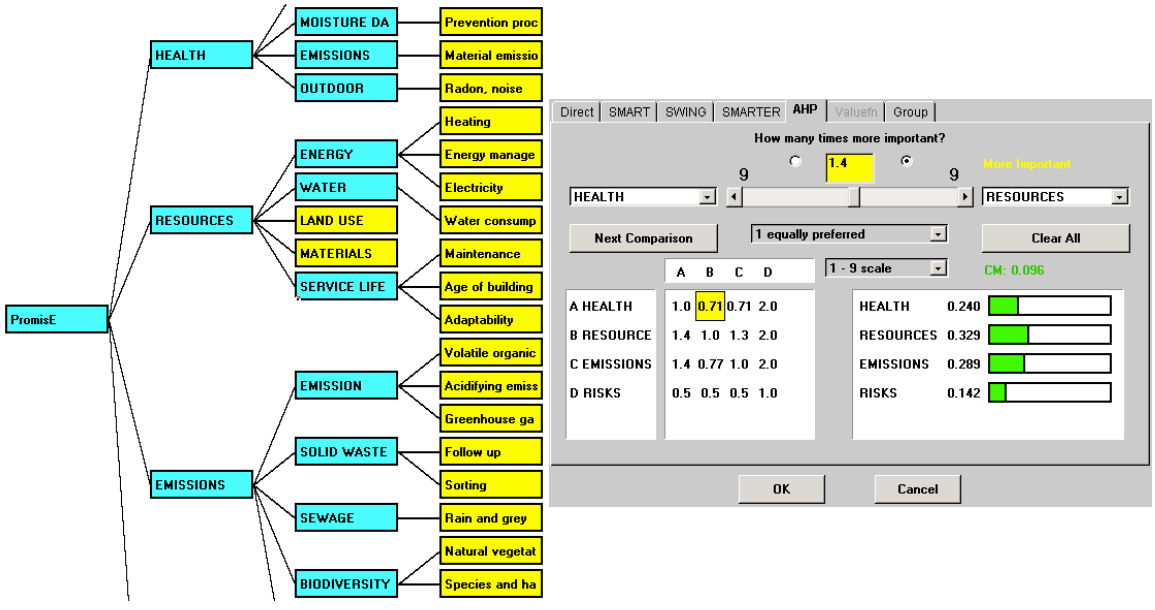

Figure 3 AHP weighting.

2.2 Analysis

Figure 4 shows, among other things, how the Production group prioritized service life higher than to the Designer group. Figure 5 shows the end results of the weights at the top level by the four groups and against the Old weights.

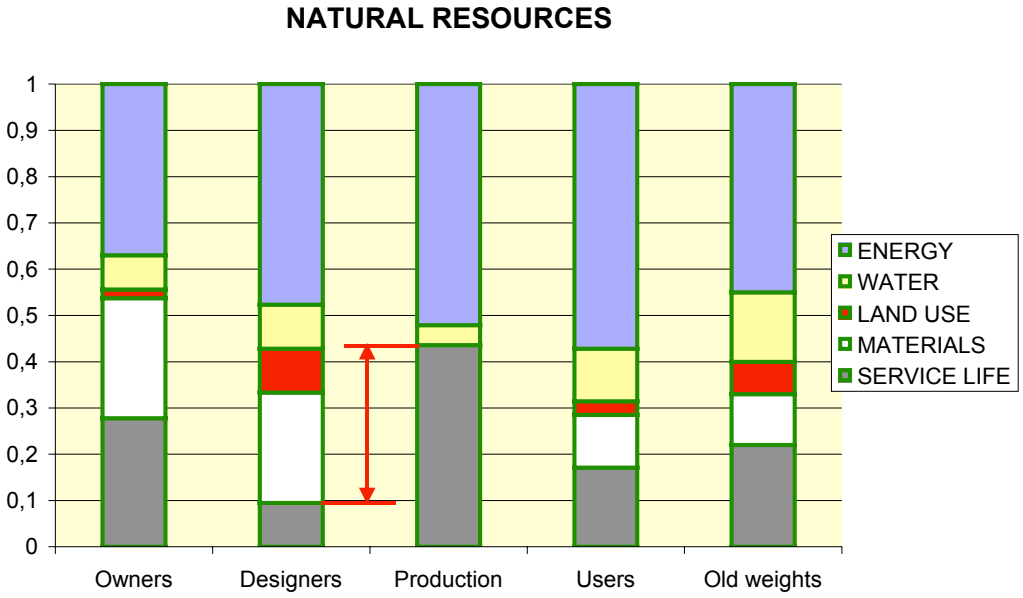

Figure 4 Natural resources as weighted in four sectoral groups, and compared with the old weights

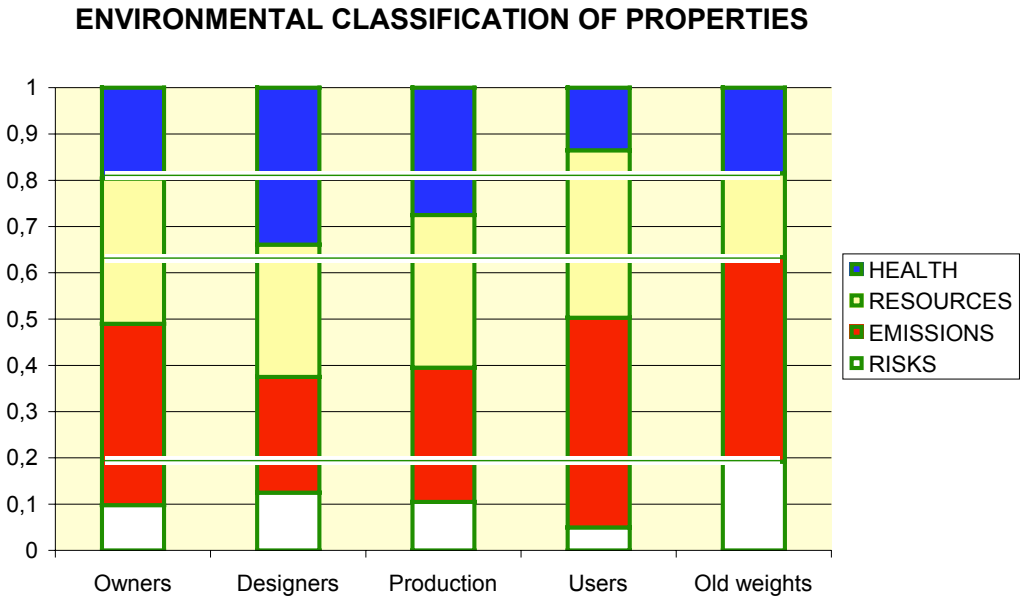

Figure 5 Weighting results of the PromisE system.

3. ENVIRONMENTAL CLASSIFICATION FOR BUILDINGS

The other case deals with an ICT firm that has a clear property management strategy and is interested in environmental matters, looking for for new office space for the potentially

increasing number of employees. Two short meetings were arranged to study different possibilities of meeting those expanding needs.

3.1 Overall structure

The VTT ProP® building property classification (Leinonen & Huovila, 2001) was taken as a starting point and applied in a slightly simplified and modified form. Figure 6 shows the system model structure with given weights .

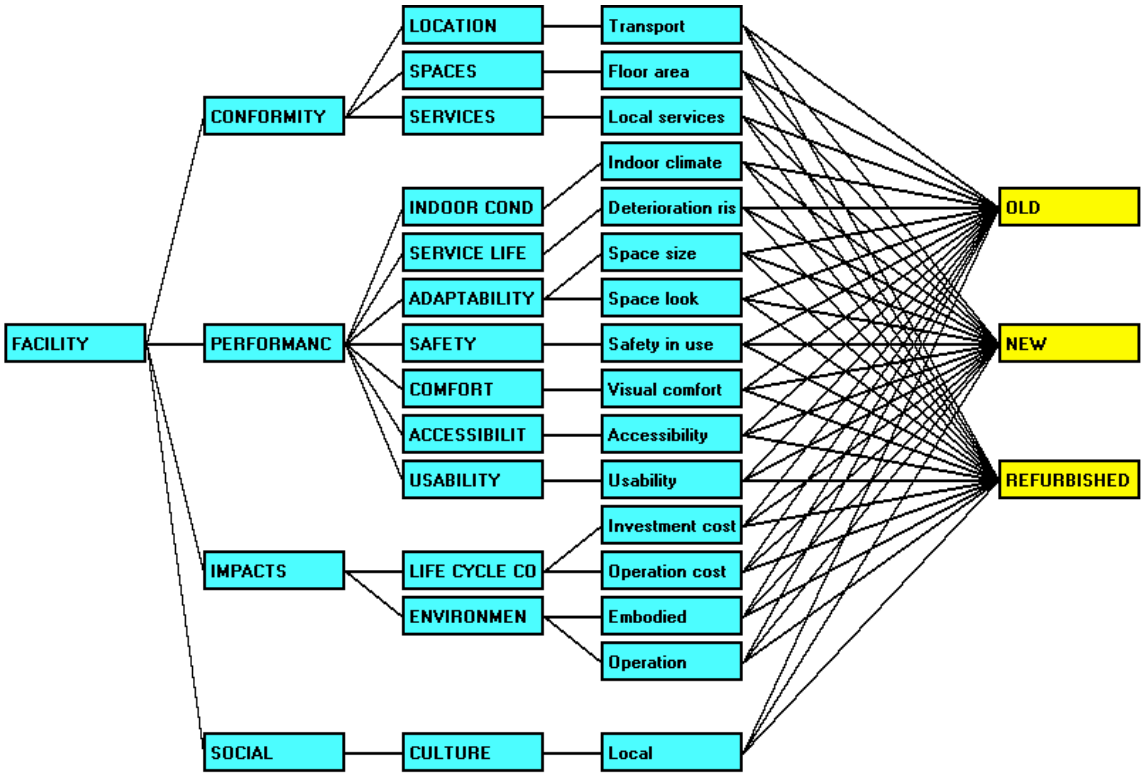

Figure 6 Three alternatives compared as the potential future facility.

Three alternative solutions were studied. The first one was an old production plant with large open spaces that could be modified as an office space. The second one was a new building to be constructed and the third one an existing building to be refurbished. The four basic categories to be examined were conformity (location, spaces and services), performance (indoor conditions, service life, adaptability, safety, comfort, accessibility and usability), cost and environmental properties (investment cost, operation cost, embodied environmental pressure and environmental pressure in operation) and social and cultural issues.

3.2 Analysis of results

Using the described model with its weights the old building showed to be the most tempting choice, at least to be started with. Figure 7 shows in detail that the high level of adaptability with large open spaces made the old plant most attractive of those three alternatives.



Figure 7 Adaptability (level 2) and Space size (level 3) as major individual factors.

Figure 8 proves how social and cultural issues also supported the selection of the old alternative. The sensitivity analysis shows that with a considerably bigger weight of cost and environmental properties than it was (0.23), the refurbished alternative would have overtaken the old one.

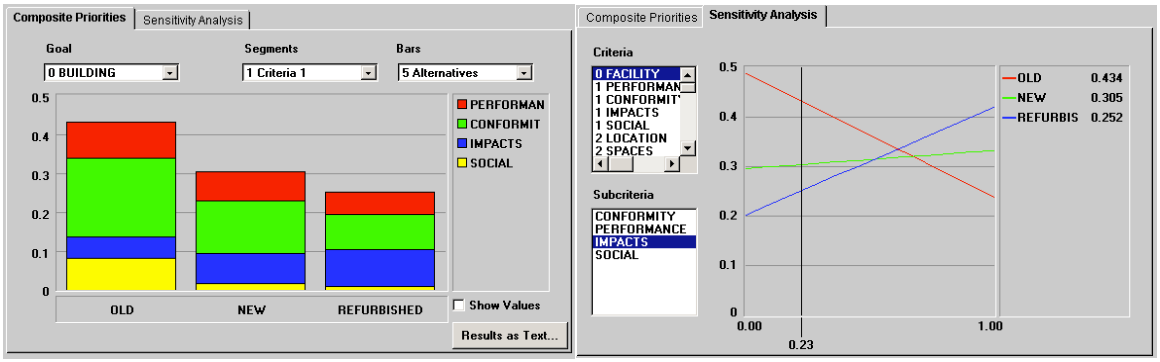

Figure 8 Composite priorities and Sensitivity analysis.

4. DISCUSSION

The Web-HIPRE tool was applied in two cases. In the first one, attaining weights (or valuable reference data for setting the weights) for an Environmental and Classification System. It served as a transparent teamwork tool helping the substance experts with visual aids to follow a logical path and end up with reliable weights that can be agreed on. The feedback was positive. In second case, Web-HIPRE served as identifying hidden objectives and keeping them part of the decision-making procedure. Environmental objectives are often present in official statements, but in real life kept in a side track. When they are modeled as part of the system, the user is forced to give them weights and therefore think what it really means if they are wanted to be kept as part of sustainable business processes.

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Leinonen, J. & Huovila, P. 2001 Requirements management tool as a catalyst for communication. In: 2nd Worldwide ECCE Symposium. Information and Communication Technology in Practice of Building and Civil Engineering. Espoo, 6-8 june. Association Finnish Civil Engineers RIL. pp. 105-110.

Model for Integrated Environmental Management System in the Design Phase

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SUMMARY
The objective of the project has been to develop a model for Environmental Management system in the design phase.

Different work groups for respective buildings , roads and onshore pipelines, have developed process-designed models for Environmental management system for each sphere.

The project results are displayed in a project web.
The project web has been used throughout as a project information system. All project members have permission to the web through a password. When the project is finished the project web will be free for all who are interested in reports and the Environmental management system.
Included is also a terminology list and links to other relevant web-pages.

The project has developed a program for implementing environmental management in organisations.

The project also has developed a training program in environmental management.

BACKGROUND
The construction industry has in general little focus on systematic environmental management in projects. The design phase is the most important stage to set the terms for environmental management through the life cycle of the project.

Interconsult, who has had the management of the project, has used own organisation as case for developing the model for environmental management for designing a building. The system is based on ISO 14001 and ISO 900:2000, and Norwegian legislation.
The objective of the project is as follows:

- Part I. Developing a model for integrated environmental management for the design of buildings
- Part II, Developing and adapting tools and examples of best practice for the best environmental choice in design and construction.
- Part III, Developing an electronic handbook and a training program in environmental management.

The project is financed by the Norwegian EcoBuild Program, in cooperation with The Directorate of Public Construction and Property, The Directorate of Defense Construction and

Property, The National Higway Departement, the piping company Br. Dahl, Association of Consulting Engineers and Norwegian Association of Consulting Architects.

Following companies and departments have participated professionally in the project:

- The Norwegian EcoBuild program
- Directorate of Public Construction and Property
- The Directorate of Defence Construction and Property
- The National Highway Department
- The Highway Department Akershus
- Br. Dahl
- Association of Consulting Engineers
- Association of Consulting Architects
- Interconsult
- Fredrikstad County
- AS Anlegg
- Selmer Skanska

Environmental management

The model for Environmental management is based on ISO 14001, the international standard for Environmental Management, with focus on external environment. Also included, in accordance with Norwegian Legislation, are the Planning and Building Regulations Act and The Working Environment Act. The Environmental Management System is thus dealing with safety, working environment, building indoor environment and natural environment related to the different types of projects considered.

Organisation of the project.

The project was initiated by the consulting firm Interconsult ASA, and the firm is in charge of the project management.

The project has been segmented in several subprojects:

- Managing Group, leading the project
- System Project Group, developing system structure for the Environmental Management System
- Building Group, working out system elements/ tools for the Structure discipline and for the HVAC-discipline in building design
- Road Group, making system elements/ tools for the road discipline
- Pipeline Group, making system elements/ tools for pipeline discipline

The model developed has been tested in several pilot-projects by representatives involved in those projects, thus being of practical assistance for the disciplines.

The project has been organised in following project groups:

1. Managing group, with participants from companies and departments financing the project. This group has the commission to manage the project, approve project plan, following up the accomplishment of the project and contribute to further financing of the project.

2. System Group has developed principal model for environmental management system according to ISO 14001, in addition to developing specifications for the web-sides, developing training program and defining terms to be applied in the project.

3. Building Project Group. Developing and testing check lists and tools for environmental design, involving several case projects, and developing a process model for building design.
   The working group has used following case projects for their work: Helsebygg, Kvinne Barn-senteret. Statens Hus Sogn&Fjordane, FBT building 64. The result of the Group is presented in process chart for building design.

4. Working Group Pipelines. Developing and testing check lists and tools for environmental design, involving several case projects. Developing a process model for pipe line design. The working group has used following case project for their work: Main water pipelines of Kråkerø, Fredrikstad. The result of the Group is presented in process chart for pipeline design.

5. Working Group Road Construction. Developing and testing check lists and tools for environmental design, involving several case projects. Developing a process model for road construction design. The working group has used following case projects for their work: Highway 35 Hadeland-Gardermoen, Road to Office park of Alnafoss. The result of the Group is presented in process chart for road design.

Environmental management system of Interconsult

Interconsult has used the experience of the project to start developing its own environmental management system, which includes environmental aspects of company operation as well as projects. Plan for developing and implementing the environmental management system is composed.

The environmental management system of Interconsult is presented on the intranet of the company, integrated with the main management system of the company.

The web solution

The project has developed its own project web based on Microsoft web-platform and internet information server.

The project web has been open for a closed user group with defined user names and password. For each working group it is possible for all group members to publish papers accessible for all participants.

The project web is divided in two parts, one part open for public, and the other part accessible for project members only. All general information and project results are open for public. The closed project part contains project management and other project related information as minutes of meeting ie.

Development of the project information web-sides has been a part of the project, and the experience and result of this is of general interest for use in other projects.

In principal all types of information and documents can be published on the project web, and the user can from his own browser manage the document flow.

Project results
Project web. The project results are presented in the project web.

There are three different process charts, relating to Buildings , road construction and pipelines. The process structure give relevant information about activities and tools for respective project phase.
For each activity you will find what to be done, who has to be involved and relevant tools and examples from other projects. You will also find links to other web-pages of interest.
Requirements in ISO 14001 is given as reference to relevant paragraph in the standard in each activity. Reference to Norwegian Legislation is given as links to respective laws and regulations.

Other information in the project web:

- Presentation of the case project where tools and examples are found
- Links to relevant information for environmental management
- Information about the participant in the project, companies and persons
- Terminology

Edifying of qualification. One important objective of the project had been to edify the qualification of the participants in the project.
The project has been accomplished as development project where all project members have taken part in the development.
The process charts and tools are developed in work-groups, and the group members have established both system and professional skill, and will be able to handle the environmental management in projects to come.
The project has consisted of several work groups with a large number of persons involved, and the knowledge and consciousness of environmental management in design and construction has got a good propagation in the branch.

Training program
The project has developed a training program in environmental management with following elements:

- Requirements in standards and related Norwegian legislation
- The EcoBuild Program, and results
- Environmental management in companies, system solutions and implementation
- Environmental management in projects

A test course is performed for the project members to make necessary improvements of the course before it is opened for general public.

Table 1. Process chart, building and construction.

Process performance	Activities	Responsi-bility	Tools, examples	ISO 14001
Environmental management in companies	Determine politics Implement environmental management system		Main environmental management elements Examples environmental policy Environment management system: Plan for implementation	
Environmental management in project	Goal analysis Priority of environmental action Foundation		Goal analysis M3P project Priority of environment action M3P project	
	Basis: - Identify Environmental specifications and users specifications		Example; check list legislation Procedure; project start up Check list; project start up	
	Organizsation/ responsibility: - Appointment H&S		Job description: H&S-co-ordinater Appointment H&S-co-ordinater	
	Project management		Guidance environment correct design Risk management Waste management	
Program phase	**Define main goals for the project**	BH	Check list important environmental aspects: -Ecoprofile -MIPP -GBA, Green building design	
	Identify environmental requirements in relation to functions	BH	Example; environmental follow-up program:	4.2 4.3
	Cause and effect analysis Priority of activities.		Legislation Cause and effect analysis	
	Determine environmental specifications in contracting designing companies	BH	Examples Performance environmental specifications to contractor, Statsbygg	

Process performance	Activities	Responsi-bility	Tools, examples	ISO 14001
Sketch phase	**Public handling** - In advance conference **Evaluate environmental goals** **Clear up alternative solutions**	LE	Check list for identifying environmental specifications and criteria of acceptance Tools for complete evaluation of buildings, ENVEST Report from the sketch phase	
Preengineering	**Project development** **Explain consistency, priority** **Define functional requirements and solutions**	LE	H&S- plans: Criteria of acceptance Examples ROS-analysis: Helsebygg; environmental and energy effective solutions:	4.3.4 4.4.6
	Contaminated soil		Byggdetaljblad 511.211 Planning for building on contaminated soil	
	Application for acceptance of building and construction		Application form BE	
Detail projecting	**Detail solutions**	LE	Check lists:	4.3.4 4.4.6, 4.5.1, 4.3.1/4. 4.7
	Document solutions	E	Example material selection Environmental correct selection of building materials Folksam material guide Example waste plan: Example H&S-plan	4.4.6

The Finnish Environmental Assessment and Classification System (PromisE)
Current State and First Experiences

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1. INTRODUCTION

An increasing number of companies in the real estate and construction sector see a business opportunity in environmental issues. The environment must be taken into account in order to minimize unnecessary risks and to uphold a positive corporate image. Solutions that are friendly to the environment are often also economically viable in the long term.

The greatest challenges and opportunities lie in the added-value factors related to environmental values. Clients are showing growing interest in environmental issues, and the demand for environmentally friendly products is increasing. Examples may be found in tourism, hotels, retail chains and housing. Although the importance of 'green' values is increasing, it is not easy to market a building using environmental arguments.

A significant factor in these marketing difficulties is a vagueness concerning what 'environmentally compliant' or 'environmentally friendly' actually mean. The environmental impact of a building over its entire life cycle of several decades consists of a number of factors that clients cannot be expected to be conversant with. Distilling the environmental properties of a building into a concise and attractive package is an absolute must for marketing to succeed.

PromisE Environmental Classification System for Buildings is being developed in order to support this market development. PromisE is a marketing tool whose basic idea is to evaluate the major environment effects of a building with simple but dependable indicators. The results are awarded points, and the building is given a grade, which reflects the quality of its environmental properties. The classification enables buyers or tenants to assess the 'environmental friendliness' of a building classified as Class A, B, C, D or E just as with household appliances.

Environmental classification is intended as a tool for all actors in the property, construction and building services industry. The environmental impact of a building consists of its design solutions, the products and materials used in its construction and also the way the building is

used and maintained. Environmental classification helps create a shared view of what 'environmentally friendly' means in practice.

2. ENVIRONMENTAL CLASSIFICATION FOR BUILDINGS

Underlying the environmental classification is a decision in principle taken by the Government in December 1998 concerning the promotion of sustainable construction. The development and introduction of an environmental classification system for buildings is mentioned as a key market-driven development measure in that decision.

Environmental assessment and classification systems for buildings have been and are being developed in a number of countries: Ökoprofil in Norway, EcoEffect in Sweden, BREEAM in Britain, BEPAC in Canada and LEED in the USA. The most widely spread of these is BREEAM, which is used to classify 30% of all new office buildings in Britain.

The structure of the classification, the things it measures, the weight and indicators of these measurements and the reference levels are complete and posted on the Internet for comment. The indicators are divided into four categories: human health, use of natural resources, ecological consequences and environmental risk management. The categories consist of more detailed criteria assessed with the indicators selected.

2.1 Human health

Human health (figure 1) is part of the PromisE system addressing to the health issues of people staying indoor. Emissions, moisture risks and infiltrated outdoor air pollution are given measurable indicators that can be used when assessing human health in buildings. Human health is weighed as 25 % of the PromisE system.

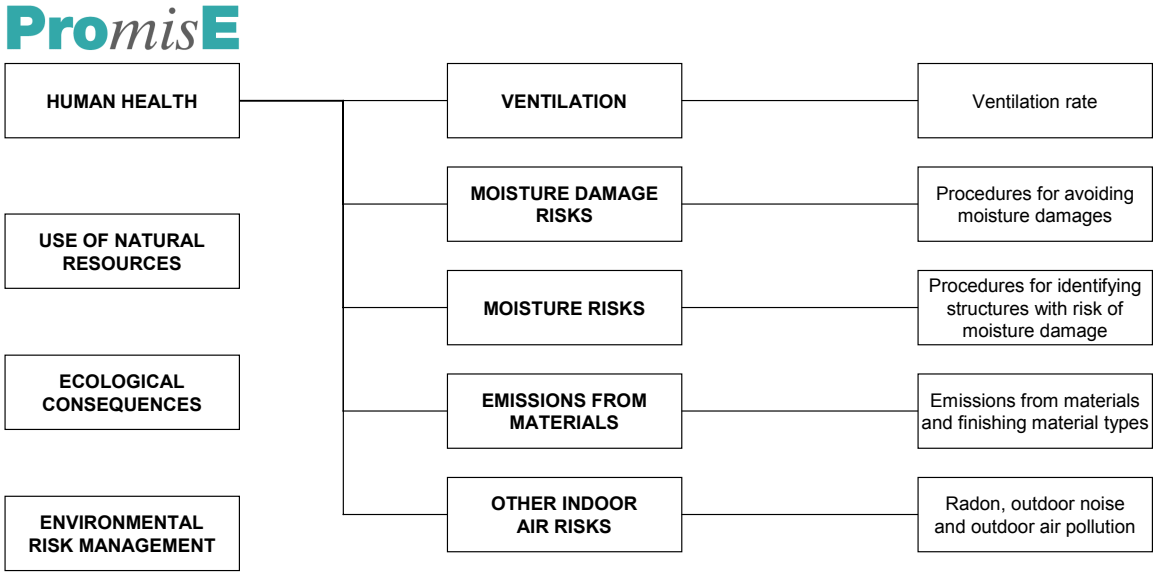


Figure 1 Human health (25 %).

2.2 Use of natural resources

Use of natural resources (figure 2) emphasises energy, water and service life. Since there aren't yet simple methods for considering the land use and materials issues they are, for the time being, left out from the system. The service life part includes service life design, flexibility and adaptability, and procedures for systematic maintenance planning. Thus, the

materials omission is partly compensated by the service life items. The weight factor for natural resources is 15 % of the total system.

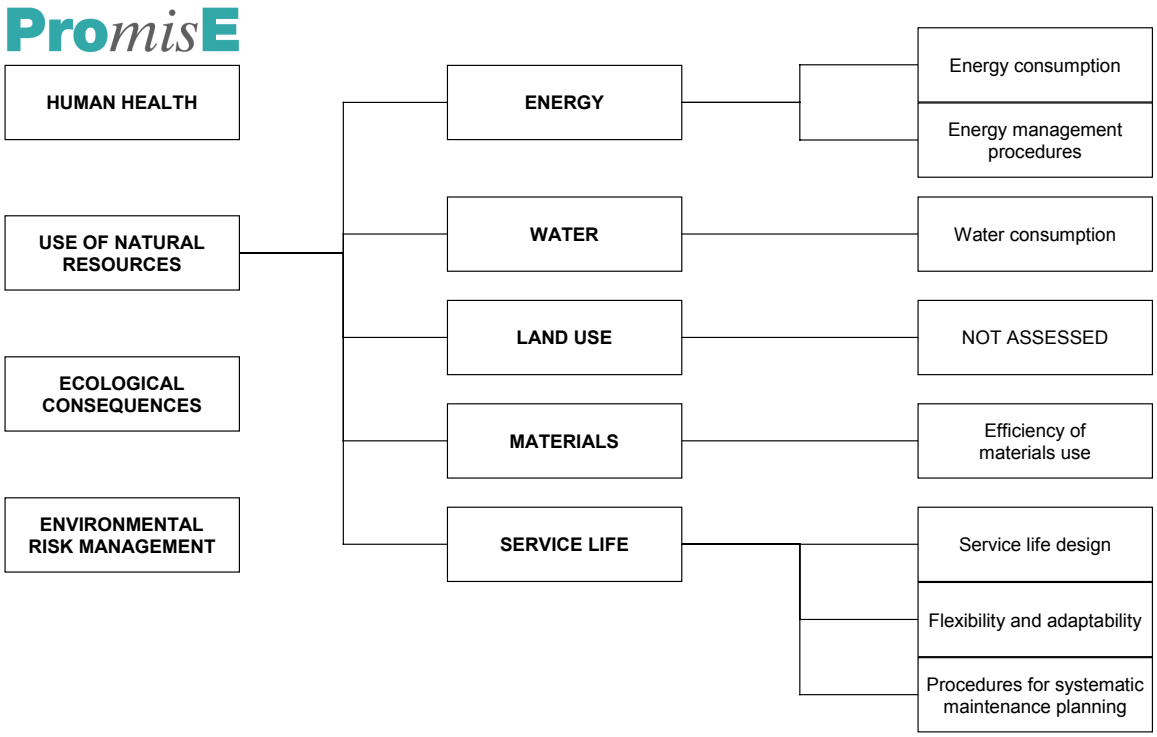


Figure 2 Natural resources (15 %).

2.3 Ecological Consequences

Ecological consequences (figure 3) are counted from emissions to air, solid waste and sewage, local biodiversity and emissions from transports. Emissions to air (greenhouse gases, acidifying emissions and volatile organic compounds) is the most important group of parameters under ecological consequences. The structure of waste and transports categories differ depending on the building type in question. Ecological consequences are weighted to represent 40 % of the PromisE score.

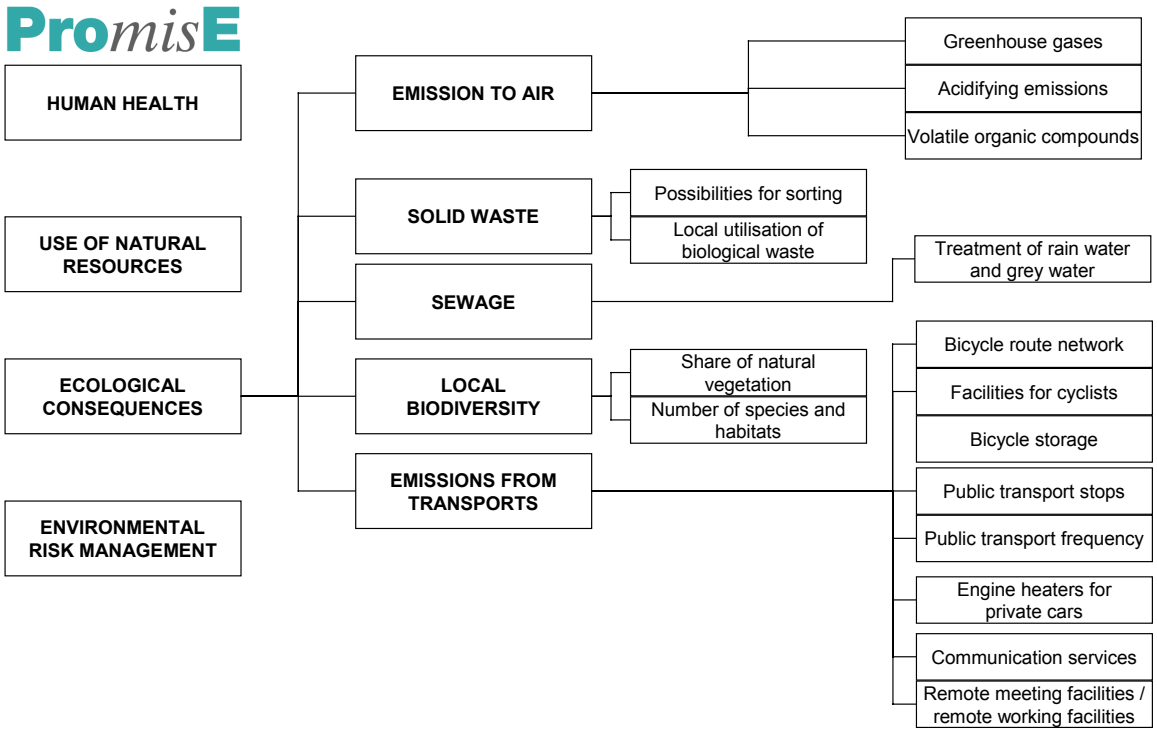
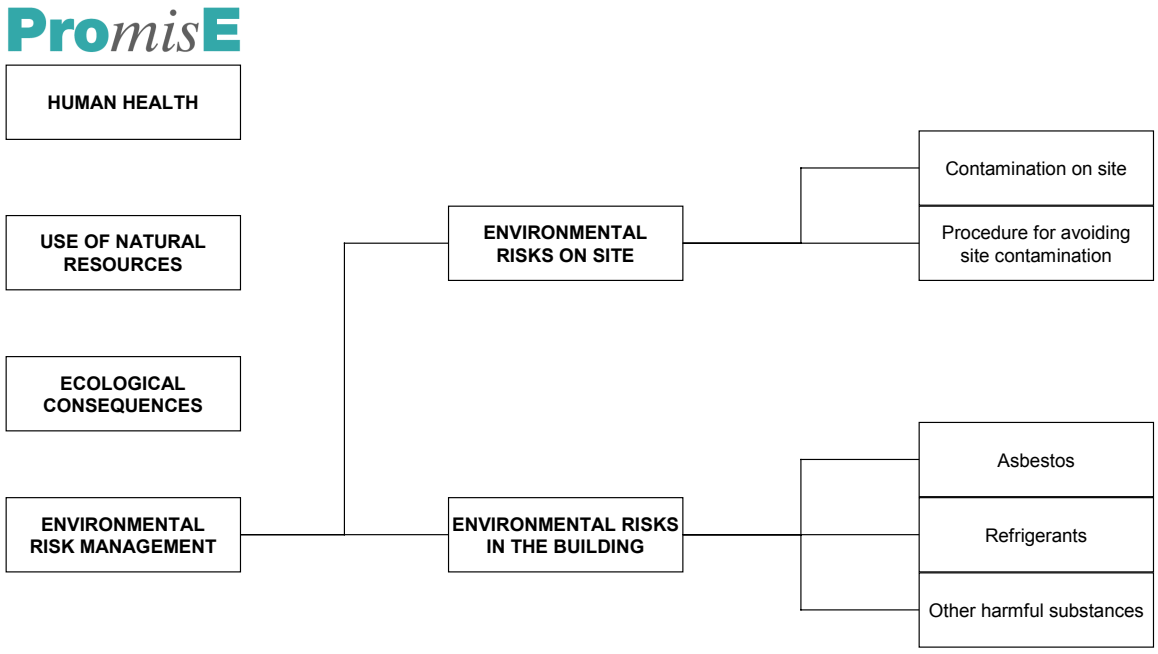


Figure 3 Ecological consequences (40 %).

2.4 Environmental Risk Management

Environmental risk management is defined as measures taken in order to identify and eliminate potential environmental risks on site and built into the building itself. These include measures related to contaminated land and harmful substances. Environmental risks may lead to operations with major environmental impacts if they are not identified and dealt with in time and systematically. In an existing property these may remain harmless until refurbishment takes place or something unexpected occurs. The share of environmental risk



management in the overall score is 20 %.

Figure 4 Environmental risk management (20 %).

2.5 Current State

At the moment, the classification system is being shaped into a tool usable over the Internet. The tool will accept input on a building and calculate which class the building falls into. The tool will be tested with pilot projects during the spring, and the results from these projects will be used to develop the classification further. The classification for housing, offices and shops will be completed in autumn 2002.

Project participants:
Management and piloting:
Senate Properties (offices)
Helsinki City Real Estate Office (offices)
Sampo Group, Kiinteistövarma (offices)
The City of Helsinki Housing Production Department (housing)
Asuntosäätiö (housing)
The VVO Group (housing)
The S Group (shops)
Kiinteistökesko/ Kesko Corporation (shops)

Research and development:
Motiva, Energy Information Centre
VTT Building and Transport
JP-Building Engineering Ltd
Finnish Society of Indoor Air Quality and Climate

Coordination:
RAKLI The Finnish Association of Building Owners and Construction Clients

3. FIRST EXPERIENCES AND NEXT STEPS

The Finnish Environmental assessment and classification system (PromisE) is still under a development and testing phase. The systems structure as presented in this paper is already established, including data sheets for input data collection and evaluation sheets for the assessment. The system has weights that can be revised and adjusted if so desired and the first version of the technical internet solution is almost ready.

The contents of the classification system (data gathering, indicators and assessment) were tested by the participating companies in six buildings. Experience gathered from these first pilot studies were incorporated in the final development of the system.

The PromisE Internet tool will be published during summer 2002 for use by building owners and other interested parties. Next steps after the publication of the tool will include the implementation of a marketing and dissemination programme and the establishment of a system of authorised assessors for carrying out public building rating.

4. REFERENCES

http://www.rakli.fi/progress/english.htm

The research of dwelling service facilities viewed from the angle of sustainable development

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1. INTRODUCTION

From UN Conference on Environment and Development held in Brazil at year 1992, to Human Settlement Conference held in Turkey at year 1996, and all the way to World Conference Climate Change 2000 held in Netherlands at year 2000. The Sustainable Development Issues have become one of the most important issues to the global community. In 1996, the Taiwanese government has established the Sustainable Development Committee of the Country. The Executive Yuan emphasizes Green Building as the integral part of Sustainable Urban and Rural Development Policy. The major issues of this research include two parts as following:

1. The possible trends of how sustainable development affects dwelling service facilities
2. The present state of urban dwelling service facilities viewed from the angle of sustainable development in Taiwan

First, by reviewing related literatures, we integrated the histories and definition of sustainable development. And collected the relative assessments we summed up the main concepts in the field of environment design. Furthermore, we sorted out the possible trends and objectives of urban dwelling service facilities from the issues of sustainable development to help us define the characteristics and construct the assessment framework of urban dwelling service facilities.

Second, we took sampling questionnaires and surveys on dwelling service facilities in 4 major urban areas in Taiwan（Taipei, Taichung, Tainan, Kaushong）. Finally we did the statistical analysis on the data.

2. THE SUSTAINABLE URBAN DWELLING SERVICE FACILITIES

2.1 Definition

The concept of sustainable development has its origin in 1970 with a history roughly about 30 years. The key issues of sustainable development have changed from single, separate issues of environmental problems to various issues related to sustainable development. Its field of application also has expanded from the fields of environmental protection to include planning and design fields. So the definition and the related issues of sustainable development are different by field of application. In general, dwelling service facilities stress the need to meet the basic living requirements and to enhance the living standard at the expense of the

environment pollution, energy consumption, and spent resources. The green dwelling service facilities start to consider how to reduce the consumption of energy and resource, and to diminish the pollution of environment despite of putting a strain on the economy. The sustainable dwelling service facilities try to find renewable, reusable, recycling and integrating application of energies and resources. It tries to reach an ecological balance and promotes the balance among the economy, environment and culture within the society, From this discussion of the sustainable dwelling service facilities, we will define it as following：

Sustainable dwelling service facilities must meet the user's basic living requirements which consist of safety, health, convenience, and comfort. It can efficiently reduce the consumption of exhaustible energy and resources and reduce their impact on the environment. It is adaptable, flexible, and easy-maintenance enough to meet possibly need and change that arises in the future. It must actively incorporate the new technologies such as recycling, information and communication systems. It also must follow and preserve the existing local environment and culture.（Fig1）

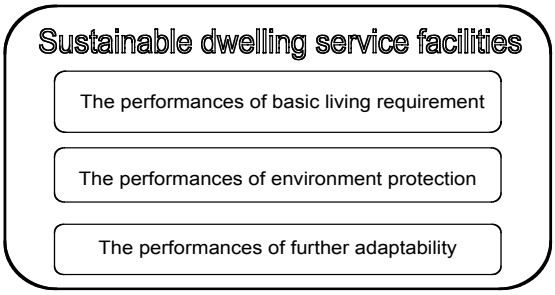

Fig.1 The performance concept of sustainable urban dwelling service facilities

2.2 The index and framework of sustainable urban dwelling service facilities

In order to discuss sustainable development's influence on dwelling service facilities' future development, we need to understand the present state of urban dwelling service facilities. We use the definition of urban sustainable dwelling service facilities by this research to address the framework of investigation and assessment. The framework includes three main issues that are the performances of basic living requirement, environment protection, and further adaptability. We refer to the assessment frameworks of BREEAM[1], LEED[2], GBC2000[3], Symbiotic Housing A-Z [4], and GBES2001[5] sifting out the indexes that are related to the research and bring it into the framework of this research. Furthermore, in accordance with the characteristics of urban dwelling service facilities in Taiwan, we add some relativity indexes. The finally investigation and assessment framework is as show in Fig.2.

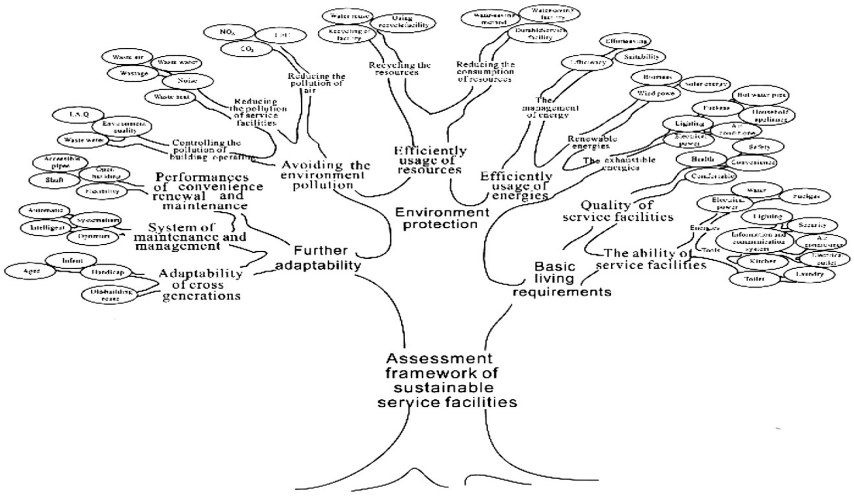

Fig.2 The assessment framework of sustainable service facilities

3. THE INVESTIGATION ON THE URBAN DWELLING SERVICE FACILITIES

3.1 Methodology

By use of questionnaire and field data-collections, this research was based.

1. Questionnaire: The questionnaires were sent to the inhabitants who belong to the sample group in the experiment. The questionnaire tries to gauge the degree of inhabitant's satisfaction with dwelling service facilities, find out about the inhabitant's opinions, and find out the condition of dwelling service facilities maintenance.

2. Field data-collections: Hired professionals handled the tasks which require professional expertise. The bulk of field data-collections includes drawing the sketches of dwelling planes, lighting laying-out planes, electric outlet laying-out planes, TV-outlet laying-out planes, Tel.-outlet laying-out planes, AC laying out planes etc. Furthermore, we also gather the data on each dwelling's energy consumption（including water, electric power, and fuel gas）.

The investigated urban dwelling service facilities in this study consist of bathroom, kitchen, laundry, air conditioner system, lighting system, electric-outlet system, information and communication systems, security system, electric-supply system, fuel-gas supply system, and water- supply system. In the case of apartment, we only investigated the dwelling service facilities of privately owned.

Using the statistics from "The population statistics of Taiwan in 1999" and "The population and inhabitation investigation of Taiwan in 1995" published by the auditing department of the Executive Yuan, we set the sample ratio at 0.005% in this study. The actual sample ratio is 0.0058% and number of validly sample is 205, and the scale, the average number of inhabitant and floor area for each type of dwelling of the samples as show in Tab.1 and Tab.2 .

Tab.1 The scale of dwelling unit investigated

		Taipei	Taichung	Tainan	Kaushong	The public housing	The average
Average inhabitant per unit dwelling (person/unit)	Research results	4.34	4.24	4.58	4.22	4.18	4.32
	A.D.,1995	—	—	—	—	—	3.77
Average area of floor per unit dwelling (PIN/unit)	Research results	36.23	51.43	43.91	40.50	27.9	39.49
	A.D.,1995	31.5	35.4	34.75	33.37	—	34.23
Average floor area per inhabitant (PIN/person)	Research results	8.61	13.03	10.74	10.53	6.86	9.75
	A.D.,1995	7.86	8.75	8.08	8.42	—	8.14

[A.D.:The auditing department of the Executive Yuan, 1995][1PIN=3.3M^2]

Tab.2 The average number of inhabitant and floor area for each type of dwelling

	Town house	Apartment	The public housing	The average	The auditing department(1995)
Average inhabitant per unit dwelling（person/unit）	4.98	4.11	4.18	4.32	3.77
Average area of floor per unit dwelling(PIN/unit)	57.02	33.80	27.9	39.49	34.23
Average area of floor per inhabitant (PIN/person)	8.75	7.86	6.86	9.75	8.14

[The auditing department of the Executive Yuan, 1995] [1PIN=3.3M^2]

3.2 The evaluation of dwelling service facilities by inhabitant

General speaking, the total satisfied degree (include satisfied and very satisfied) of dwelling service facilities by inhabitant in the group of Town house is 48.0% ; in the group of apartment is 55.1% ; in the group of the public housing is 40.9% . And the unsatisfied degree (include unsatisfied and very unsatisfied) is under 10% . By items of satisfaction, the highest satisfied degree(include satisfied and very satisfied) item is electric supply system (about 65.0 %) , the secondly is fuel-gas supply system (about 62.3%), and then is lighting system (about 59.0%). On the other side, the highest unsatisfied degree (include unsatisfied and very unsatisfied) of dwelling service facility is laundry (about 27.1%), the secondly is electric outlet system and then is security system (about 21.5%), as shown in Fig.3.

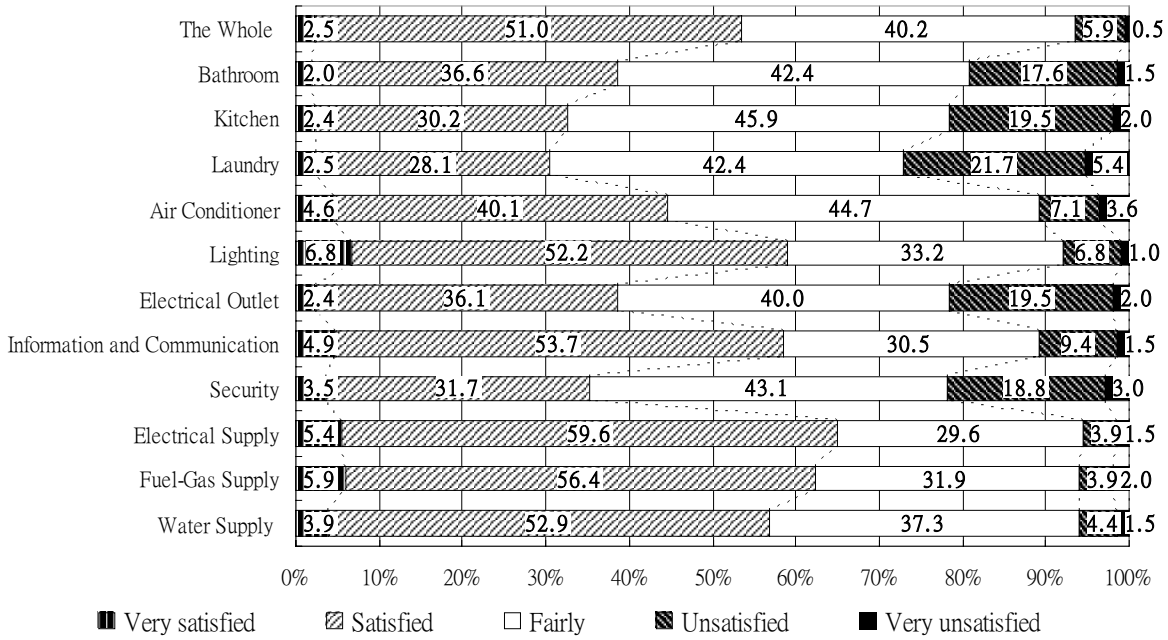

Fig.3 The satisfaction degree with dwelling service facilities of the inhabitants

4. THE SUSTAINABLE ASSESSMENT TO CONVENTIONAL URBAN DWELLING SERVICE FACILITIES

4.1 The analysis of basic living requirement performance

Comparing the results from the investigation with the related equipment standard of dwelling service facilities that are provided in " The planning and designing rules of the public housing community" (Ministry of the Interior, Taiwan, 1999) , we can find the following results. The results of investigation show that the ability of dwelling service facilities is higher than the requirement standard by the rules. There are 90% of investigated dwellings is conformable to the regulation, except the use of hygienic instrument with water saving device (the conformability ratio is 13.0%); the installation method of pipes system use the method of possible access for maintenance and replacement (the conformability ratio is 14.0%).

4.2 The analysis of environment protection performance about urban dwelling service

facilities

The related indexes of environment protection performance about urban dwelling service facilities, as show in Tab.3.

Tab.3 The related indexes of environment protection performance about urban dwelling service facilities

Main issues	Sub-issues	Indexes	The results of investigation
Efficiently use the energies	Reducing the consumption of exhaustibile energies	Annual electric power consumption per person	1222.1（kWh / person • year） 43.1（kWh / m^2 • year）
		Annual fuel-gas consumption per person	92.7（m^3 / person • year） 3.39（m^3 / m^2 • year）
		Air conditioner electricity consumption	The ratio of summer（May-October）air conditioner electricity consumption over annual electricity consumption is 19.9%
		Thermal insulation and length of hot water pipes	The average length of hot water pipes to kitchen is 5.21 meter; to bathroom is 7.0 meter. The ratio of thermal insulation of hot water pipe is 30.1% .
	Arising the use of renewable energies	Solar water heater	The equipped ratio of solar water heater is 2.9% .
Efficiently use the resources	Reducing the consumption of exhaustibility resources	Annual water consumption per person	76.39（m^3 / person • year） 2.76（m^3 / m^2 • year）
		Water saving device	The equipped ratio of water-saving toilet is 12.7 % .
	Using of regeneration resources	Recycle of dwelling wastage	The recycle ratio of kitchen wastage is 4.4% .
Lower the impact of environment	Avoiding the pollution of service facilities（water, noise, gas, heat, visual）	Waste water	The regular maintenance ratio of septic tank is 42.5% .
		Noise pollution	The inhabitant's complain of exhaust noise are 42.4% . Washing machine to say is 28.3% ; air conditioner is 23.9% .
		Waste heat emission	The inhabitant's complain of kitchen smoke exhaust are 39.5% . The bathroom ventilation are 19% .
		Visually pollution	The inhabitant's complain of window type air conditioner destroy the visually sight are 42.0% , kitchen smoke exhaust are 30.2% .

4.3 The analysis of further adaptability performance about urban dwelling service facilities

The related indexes of further adaptability performance about urban dwelling service facilities, as show in Tab.4.

Tab.4 The related indexes of further adaptability performance about urban dwelling service facilities

Main issues	Sub-issues	Indexes	The results of investigation
Ensuring the performance of maintenance and renewal	Ensuring the convenience of maintenance and renewal	Pipe / duct space	The equipped ratio of shaft is 43.3% . Among the samples equipped shaft, the equipped ratio of maintenance opening is 34.6% .
		Centralized state of water consumption room	The ratio of the total centralized type is23.3% , partly centralized type is 55.6% , no centralized type is 21.2% .
	Integrating the system of management and maintenance	The state of management and maintenance system	48.5% of user regular cleans or maintains the air filter of air conditioner. 1/7 to 1/5 regular cleans or maintains the fuel-gas pipe, air conditioner, and lamp. All the committee of the public housing regular cleans or maintains the water tanks every year or half-year. 55.4% of user s regular clean the water tank.

The requirement of across generations	Adapting the requirement of across generation	Special facilities for aged people	The installed ratio of related special facilities for aged people is 5.9%. And the reason to install the related facilities is for the sake of convenience of taking car, not for the reason of promoting independent living. Ex: handrail, urgent calling system, etc.
		Special facilities for infant	The ratio of related special facilities equipment for infant is 2% . Ex: baby safe fencing, security monitor etc.

5. CONCLUSION

To assess the sustainability of urban dwelling facilities should be discuss with following three orientations. 1. The inhabitant's basic living requirements; 2. Consider of environmental protection; 3. Future's adaptability. From these orientations we find out the present state and problems of urban dwelling facilities from the standpoint of sustainability in Taiwan area.

1. In orientation of basic living requirements: The quantity of the facilities can amply satisfy the inhabitant's requirements but in terms of quality, there are still a lot of fundamental problems, such as natural lighting, glare, utility space, machine noise, lack of energy electric socket, etc..

2. In orientation of the environment protection and lower consumption of exhaustible resources: Facilities equipped with energy saving or resources saving devices are not prevalent yet. The usage of facilities that capitalize on the renewable energy and reusable resources are also rare. Besides, the pollution caused by the operation of the dwelling facilities, troubles and annoys the inhabitants to a noticeable degree.

3. In orientation of future adaptability: The biggest problem is the pipe system is mostly buried into the construction. Therefore, maintenance inspections and latter renovations will be very difficult, even impossible. Also the way that the suites are set up in a dwelling prevent the concentration of the water consumption rooms, and this hampers ensued maintenance and renovation efforts. About systematic maintenance supervision, more than half of the users do not have any ongoing regular maintenance, and for those users who do, they often carry out partial, incomplete systematic maintenance supervision instead of a whole and complete one. About meeting the challenge of the new life style as we cross into the new Millennium, more than seventy percent of the dwellings have not installed the related facilities for infant and aged people.

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Eco-Office Tower: Navan Credit Union: Ireland

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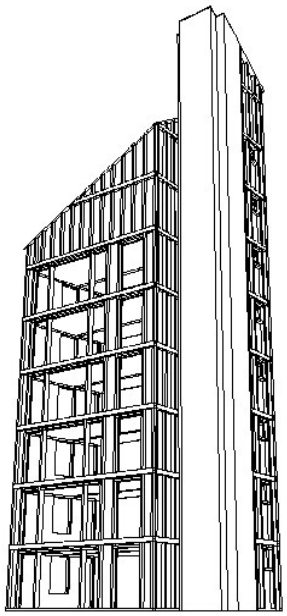

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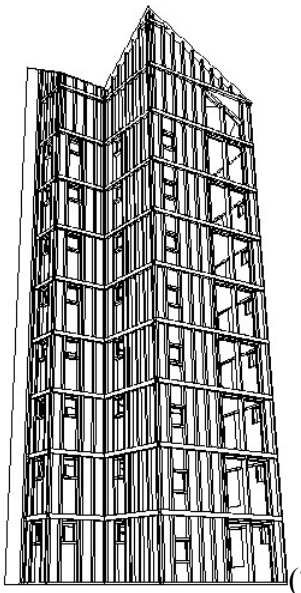


(7)

KEY POINTS: three pillars of sustainability; social, economic and ecological**.**

- **multi storey timber** structure: office building : 30 metre: ***brettstapel*** technique.
- Naturally ventilated, assisted by passive **solar chimney**. Passive cooling/ **night purging**.
- **Low embodied energy**: **Limecrete** :***baubiologie*** breathing fabric: rainwater capture
- Building Energy Management System; **50 kwhrs/m^2 /yr:'green' grid electricity**

INTRODUCTION

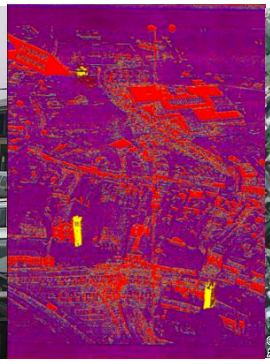
A highly successful Credit Union, (being a community financial services organisation), proposes a high quality second-phase building on 'deep' green principles. This will be an extension to the earlier (first phase) building, which may be characterised as 'light' green, completed in 1988, designed by the same architect (1). The project consists of six accommodation floors above ground with two ancillary/ plant room levels in the attenuated 'attic' spaces. There is an external lift tower, some single storey volumes at ground level, including a 'garden pavilion', banking hall, extending into the existing 'peace garden' with a new roof terrace over this.The apex of the tower is given over to a community room, an interpretative display on the history and the functioning of the Credit Union movement and the environmental performance of the building. Access to this room (over the Manager's office) will be freely available to Members and visitors. This will provide a striking view longitudinally along the proposed new Civic Space. Therefore, from both inside and outside the sense of member's *ownership* of the building is emphasised, providing a revived civic

perspective. The external elevator is designed with a vision aperture to provide an enjoyable, dynamic but secure experience (this is a low energy elevator, eg. by Kone)

ARCHITECTURAL / URBAN DESIGN CONTEXT



Photomontage



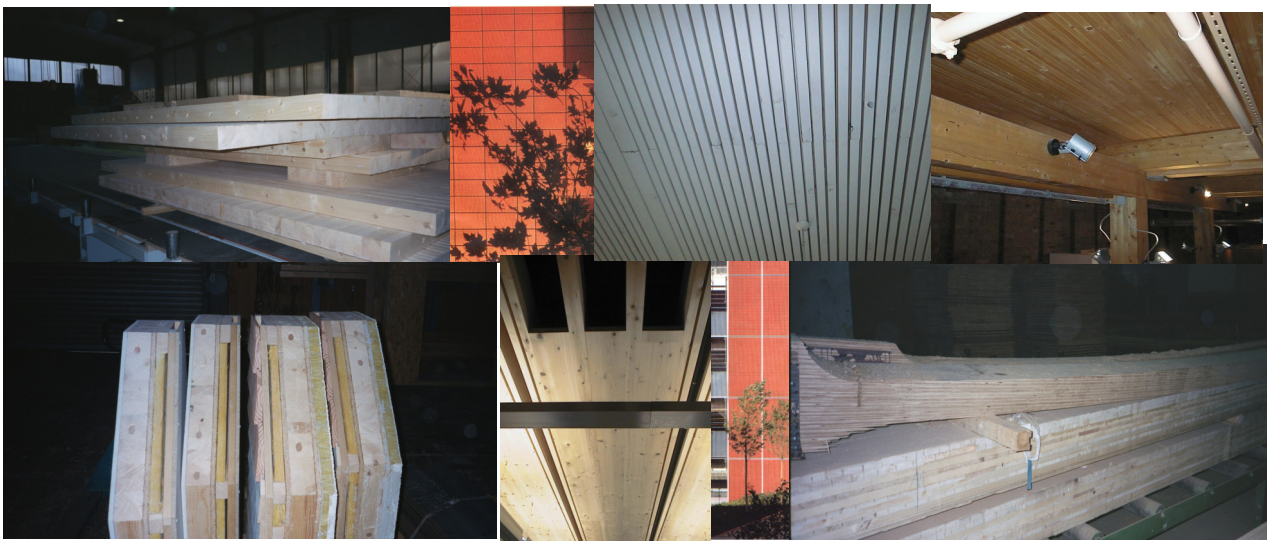
Urban Towers



Aerial View in context

This is a town centre building that attempts to add to macro townscape quality as a 'landmark' building for the 21st century, the vertical concomitant of the horizontal and longitudinal proposed Civic Space (see photomontage above, into civic space site- currently an ugly car park). The tower form has a symbolic townscape role in a degraded and now sprawling town, which is losing the quality of its historic core. It abstractly emulates the form language of the existing two church towers in the old town. Practical matters of a very confined site and difficult context also support the tower idea, which is unusual (for us) and requires rigorous justification.

TECHNICAL DESCRIPTION:



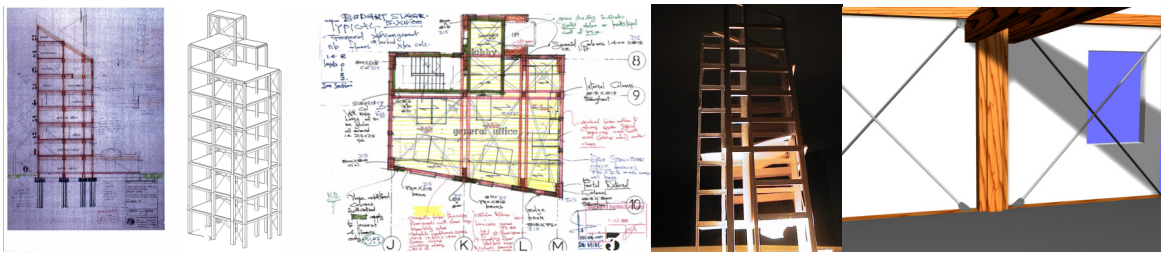
Terracotta rain screen cladding: *Holzbau/ Brettstapel*: limited *kerto* elements

Fire Safety

This matter received very close attention from an early design stage. A fire-engineering approach has been adopted and kept under review. Preliminary discussions were held with the Fire Officer, several experts have been consulted (4) (5) and conclusions have been reached, eg. the maximum height of habitable floor plate is 18 metres above ground (the fire station is adjacent and ladder reaches max.30 metres): Misting sprinkler system as recommended in US standards: Firefighting lift: Very high standard of detection and alarm: Low occupancy rooms only above 1st floor.
If carefully designed, timber structures of this height have been established by our design process to date as being feasible. Each jurisdictions has its own protocols and these must be checked on a case by case basis by designers as tests applied from first principles. Timbers structures usually depend on steel or other metal connectors. Apart from our target of low embodied energy, the issue can also be problematic in relation to fire, with the early failure of connections between massive timber components. In this respect, the *brettstapel* system being used by Merkle Holzbau of Bissingen Teck (7) is of great interest. In this system, beech dowels (at 8% moisture content) are inserted, under pressure, through slightly smaller drillings (typically at 12%MC): As the moisture contents equalise, they become an integral solid timber construction, with attractive fire safety characteristics, while retaining very low embodied energy. This component is manufactured to a quality control level that allows it to be used, as an exemplary product, worthy of support from the demand side. The downsides of transportation across Europe are, in our view, outweighed by the benefits of demonstrating this technology in Ireland. Surface Spread of Flame is a key issue and may be addressed with specialised coatings where required: care must be taken to minimise the use of any toxic substances; other fire-engineering measures may be preferred.
There is also a synergy between fire safety and acoustic considerations in massive composite timber construction. The use of imperforate fire barrier ceilings of non-combustible material with the services zone above the floor is proposed. These provide mass to damp airborne sound (14).

Transport
The Credit Union will encourage a modal split away from the private car by providing very restricted private parking and generous, secure, bicycle-parking facilities attractively designed for both members and staff. Within the building, generous showers, changing and locker facilities acknowledge the needs of staff who opt for this more sustainable and healthy mode of transport, reducing traffic congestion and pollution.

Timber Frame Construction.



(5) (5)

This would be, we understand, the tallest timber-framed office building in the world. Historic timber structures may have exceeded this in height, but we are demonstrating feasibility within contemporary practice, regulations and standards. Two types of structural system are

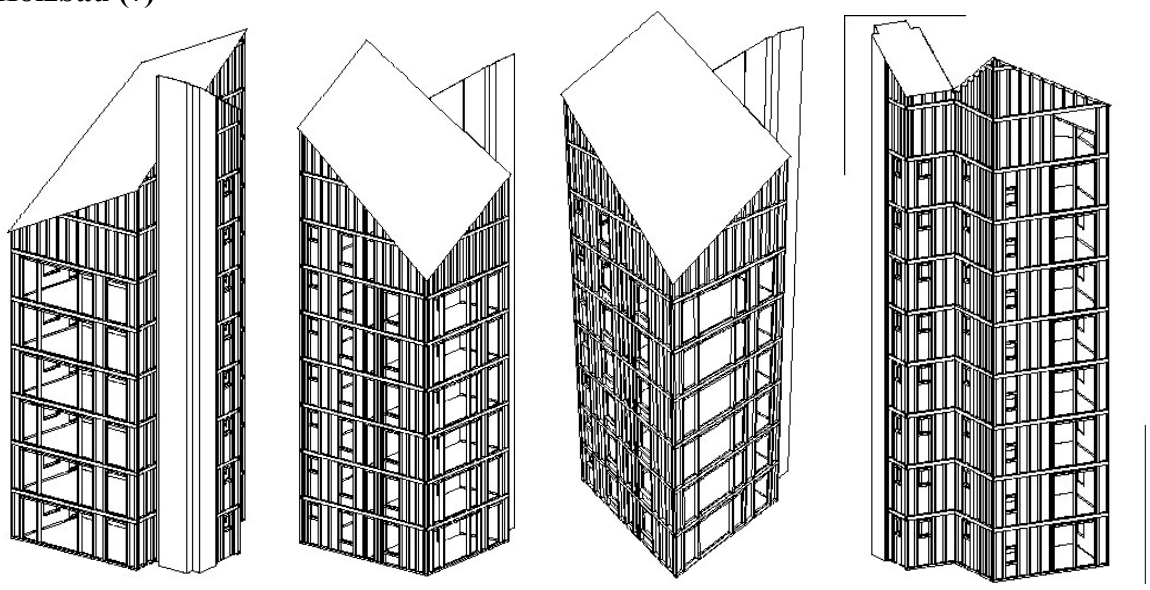
being explored: One is a rigid plate box of *brettstapel* construction with no frame.The other is a framed structure of *Kerto*/ Glulam with *bretstapel* infill. The former is preferable by ecological criteria, as glues are avoided. Detail design, calculations and modelling will establish the optimum, structurally. Calculations have been carried out to establish that the structure is in fact feasible in its present configuration (5) (7) and indicate further design in detail of connections etc.

Remarks of Gardiner & Theobald: Building Cost Consultants.
"The project consists of a mixture of new build, fit-out and refurbishment work,total budget of €4,376,787, including taxes, inflation but excluding professional fees and cost of land: new build area of 844m^2. The costings reflect the project status up to detailed planning stage and were in all cases based on detailed discussions with specialist providers. The scheme was benchmarked against "developer standard office space" using traditional methodologies, materials and components. The proposed tower would cost in the order of €1,700,000 including taxes in excess of the conventional benchmark. The factors, which created this divergence, fall into two broad categories;

(a)**Site Logistics and site Abnormals**: The proposed site is limited in terms of size, access and proximity of adjacent occupied spaces, all of which created adverse cost issues which, in turn, were compounded by known poor ground conditions. However the key additional cost arose from the high Wall to floor ratio at 1**.0**, which created a disproportionate envelope cost, structural frame cost and **relative** diseconomies due to the number of floors: The tower **form** is not justified on pure economic criteria.

(b) **Added Value:** At the outset the client embraced an holistic approach to design and life cycle cost and consequently considered and approved specification initiatives which would not form part of the typical "developer standard proposal". Aside from environmental considerations this proposal also makes sense from a site logistic perspective because of a lack of space and speed of ercetion. The timberframe created a significant additional cost, which is attributable to the lack of competitive market in Ireland for products of this nature."

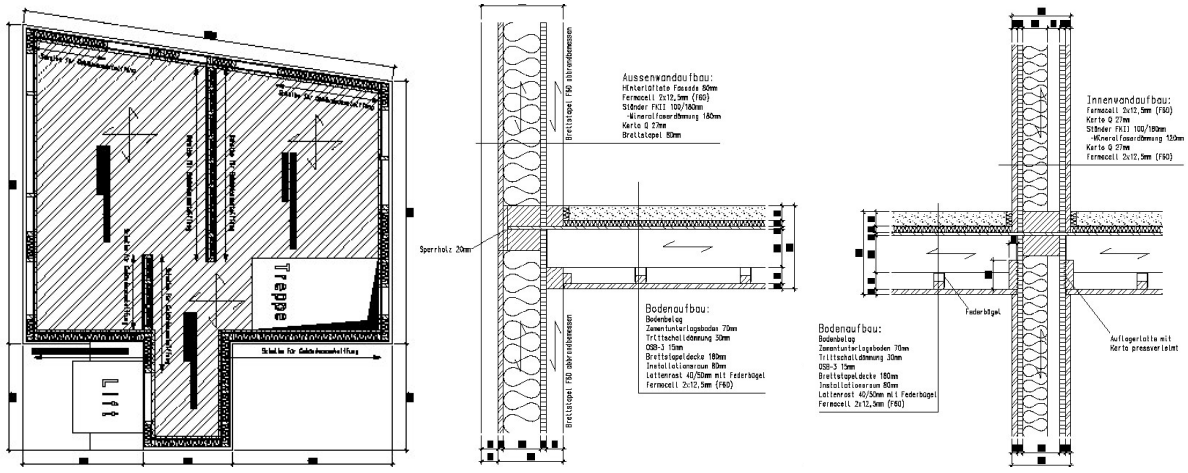
Remarks / Drawings of Pirmin Jung, Structural consultant, on behalf of Merkle Holzbau (7)



“With the Office Tower project, we are dealing with an innovative building which, with its execution, would have a far reaching global effect on the future of multi storied timber constructions. With the latest timber construction techniques, 8 storeys are absolutely possible.
The principle issue for the construction of the building does not lie in the vertical load but much more in the rigidity required by the slenderness of the building to withstand the wind factors. The effects due to vertical load in the required walls are separated from loads due to wind effects.

Fire protection can be fulfilled through assessment of burn up and encasement of the supporting structures. Increased sound insulation can be derived with the appropriate encasement of the building elements.

An 8 storey timber construction building can only be ideally constructed when both the architectural elements and statics are already integrated in the preliminary project. Therefore, early cooperation and planning between timber construction engineers and architects is essential.



Remarks of Derham McPhillips: Joseph Rooney, Environmental Services Engineer.
The use of low energy, high frequency light fittings was proposed throughout the building with photocells switching and controlling the number of lights switched on. Controlled dimming was considered but rejected because of cost. Positions of all proposed electrical equipment was closely monitored to reduce the effect of electromagnetic fields. A PV panel on the roof provided limited power for ventilation. Various mechanical options, including combined heat & power plant, thermal storage & geothermal heat pumps were initially considered but were rejected after cost benefit analysis. Air conditioning was also considered but rejected because of its high energy demand. Underfloor heating and wall heating were considered. Finally a combination of a condensing boiler with radiator circuits and a sophisticated natural ventilation system was accepted as providing the best solution. The natural ventilation system used a full height vertical duct linked to a solar chimney. Each room was connected to this vertical exhaust duct by ceiling ducts. The solar chimney provided the negative pressure within the building. Supply air was brought into the building

through the external walls. This air could be preheated as it passed over heating coils where it entered the building. There was also provision to bring cooled air into the building by drawing the inlet air over a pond in a garden outside the building. The speed of movement within the vertical duct was controlled by motorised dampers. The hot water solar panels, which provided preheated water for the calorifiers, was also linked to pipework surrounding part of the solar chimney to help generate upward air movement in the vertical duct. A small fan was also placed in a bypass of the solar chimney to provide air movement in poor weather conditions. A sophisticated BEMS was proposed to control the complete M & E installation including the motorised dampers for air movement: Night time purging would also be controlled by the dampers. Manual over-rides would be available in each room to give staff individual control, thereby widening the comfort band.

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A simulation game for sustainable decision making

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1. INTRODUCTION

Sustainable building is one of those golden concepts that succeeds in bridging the gaps between the various and sometimes conflicting interests of actors involved in the design, construction and maintenance of the built environment (Hajer 1995). However, when it comes to the implementation of sustainable building policies, the concept is no longer capable to motivate actors to build sustainably. Choices have to be made between the various values and interests represented in the sustainable building concept and in the particular project at hand, in which the sustainable building goal has to be fulfilled. The existing decision support tools often help actors to make sustainable decisions either from a scientific, analytical perspective or from a social interaction perspective but rarely the social and the technical dimensions are integrated.

Based on this ambition, the DuBes Sustainable Decision Making Project gives practical assistance to take sustainable decisions for an urban (re)construction project. The development of a computer support tool MEDIA (see Bots and Seijdel 2002 in these conference proceedings), which was used in DuBes simulation game, was part of this project. The game was developed to familiarise potential users of MEDIA with the structure and way of thinking of sustainable decision making. The DuBes simulation game and the results of two experiments - one simulation of a real and one simulation of a fictitious urban restructuring project - are described below.

2. THE DUBES SIMULATION GAME

2.1 Simulation games

A simulation game provides a safe environment, based on reality, in which the participants can experiment with decisions and negotiations (Duke 1980). The participants in a simulation game play various ‘roles’ that are derived from existing organisations and individuals. As in reality, the participants make decisions, form coalitions and make compromises based on their own goals and interests. A simulation is not primarily intended as a ‘game’ but rather as a serious, policy-oriented study, and is therefore also designated as a policy exercise (Toth 1988). Apart from being instructive, participation in a simulation game is simply enjoyable.

2.2 Urban restructuring in the game

DuBes is a method which can be applied to all types of construction projects. In the pilot project, MEDIA and DuBes have been developed for the restructuring of a post 1945 residential area with multi-storey apartment buildings. In Europe, there are some 80000 flats which need to be improved. The neighbourhoods in which these flats are located are

characterised by problems of a physical and social-economic nature (European Commission 1996). The DuBes simulation game can be played for neighbourhoods like these, real or fictitious ones.

In preparation for the game, the participants are sent the DuBes file, as it is known, containing the scenario. The scenario describes the urban planning history and characteristics of the municipality and the neighbourhood concerned, the housing stock and demographics of the neighbourhood and its problems with respect, for example, to housing, public space, water, energy, safety, traffic and transport. The DuBes file also contains an overview of the roles, the tasks and competencies of each role, and the role distribution. From 20 to 40 people can take part in each simulation. Prior to the simulation game, each participant is allotted a certain role, such as councillor, director of the housing association, director of the 'Welfare' foundation or project leader of the municipal departments for Planning and Housing, and Energy, Water and the Environment. In addition, the participants are asked to make use of their own knowledge and experience when playing the simulation.

The assignment for all participants in the simulation game is to jointly draw up a programme of requirements for the sustainable redevelopment of the neighbourhood concerned. The principal stakeholders, the municipality and the housing association owning the apartments in the neighbourhood, have decided to consult the principal interested parties in drawing up the programme of requirements. With a view to obtaining a subsidy, sustainability has to form an explicit component of the programme of requirements.

The DuBes method and tools

The project managers have a number of tools to help them achieve this difficult task in a short space of time. The most important tool is the DuBes Table. This table, in A0 poster format, schematically shows all the themes, decision fields and options from the MEDIA computer programme. Figure 1 gives an impression of the game with participants working with the DuBes Table.



Figure 1 Impression of the game

The DuBes table provides the participants with an overview of the decisions that can be made in the course of a restructuring assignment. This overview is not exhaustive. The aim of the

table is to offer the participants a guide for determining the agenda of the programme of requirements. They can therefore use the agenda when the discussion falters or runs short of inspiration or expertise, but they must draw up their own agenda.

In two sessions, one in the morning and the other in the afternoon, the participants are split up into groups to draw up their own DuBes table for the fictional neighbourhood or for a real neighbourhood. The discussions and negotiations in the groups are guided by process managers. Process managers are game participants who are instructed by the game leaders, prior to the simulation game, on the best way that they can chair and guide the process within the working groups and planning studios.

In the morning, the participants are divided into three working groups. These work from various angles of approach, such as public space, housing and welfare, to list the themes and decision fields and decide which ones must be included in the programme of requirements. As they do this, they can refer to the existing DuBes table and the DuBes advisors for guidance. The DuBes advisors are members of the Sustainable Decision Making project team (DuBes team) and they assist and advise the working groups and register their results as well as possible in the MEDIA computer program. Before the working groups commence, the participants individually and anonymously prioritise all the decision fields in the DuBes table based on how important they think a theme or decision field is for the programme of requirements. An electronic conferencing system is used for this, so that the results of the vote are available to the working groups within a quarter of an hour. The result of the first session, just before lunch, is a DuBes table for each of the three working groups to serve as the basis for the programme of requirements.

During the lunch break, the DuBes team takes the three DuBes tables produced by the working groups in the morning session and, aided by MEDIA, processes and combines them into a single, integrated DuBes table. All the themes, decisive points and options that the participants consider important for the neighbourhood's programme of requirements are now put into order and placed on the agenda in this integrated DuBes table. However, no choices have been made or strategies decided upon as yet.

In session 2, in the afternoon, the participants are asked to work out strategies for the programme of requirements in three planning studios oriented toward different aspects of sustainability, such as the environment, quality of life and feasibility. This is done by choosing, in discussions, from the options that the participants drew up in the morning. The participants are asked to reason out their choices by devoting attention to the various effects of options, including those on sustainability, and the connection with other decisions, for example decisions relating to other themes and at other levels of scale. The chosen options are marked in the table and selected in MEDIA. The planning studios are also guided by the process managers and the DuBes advisors. The MEDIA computer model registers the choices and gives extra information on the consequences of decisions, effects, consistency etc.

At the end of the day, the presentation, analysis and comparison of the three DuBes tables shows on which points the participants agree and on which points the participants have differences of opinion. On some points, the participants will have come to the conclusion that further research is necessary in order to arrive at the right choice. The DuBes tables, together with the arguments for the choices during the group discussions and evaluations, form the basis upon which a sustainable programme of requirements is drawn up for the fictional or real neighbourhood.

At the end of Session 1 and Session 2, the participants answer some questions about the process in their working group or planning studio, and about the result. This is done using an electronic conferencing system. At the end of the simulation game, the process, the result and the simulation game itself are thoroughly evaluated in a plenary discussion. Afterwards, the participants are asked to fill in an evaluation form about the simulation game.

3. RESULTS AND OUTCOMES

Up to now, the DuBes method and simulation game have been used twice in practice. In cooperation with the project bureau *Emmen®evisited* (a joint venture between the municipality and the 'Stichting Wooncom' housing association), the simulation was used on 22 November 2001 for the Emmerhout-Noord restructuring project in the Emmen municipality. On 11 December 2001, the simulation game was played, using the fictional neighbourhood, with the employees of the municipality of Alphen aan den Rijn and the 'WonenCentraal' housing association.

In both simulations, in Emmen and Alphen, the participants are generally satisfied with how the day went. They thought the simulation a good and enjoyable way of thinking about the sustainable restructuring of their residential neighbourhoods with a large number of parties.

> *It is a pleasant way of establishing objectives quickly.*
> *This way is good for forming an idea, in a short time, of the problems involved and the matters you want to resolve.*

As a consequence of the differing aims and intentions, the results and experiences of Emmen and Alphen also differ in some respects. The results and the experiences of the participants, based on verbal and written evaluations, are discussed below.

The simulation participants in Emmen are of the opinion that the method is suitable to get a good overview of the problems and possibilities raised by a restructuring project. According to them, the method is particularly useful at a very early stage of the planning process. They therefore feel it is a pity that the method was not used at an earlier stage for Emmerhout-Noord.

Despite the rather advanced stage of events, the simulation produced some ideas for Emmerhout-Noord. In particular, the municipal Spatial Planning and Housing Service, the *Emmen®evisited* project bureau and the Wooncom housing association have gained some useful ideas during the simulation on the themes of water and mobility. These included some very practical and simple ideas, such as having rain barrels by the houses, and also more all-embracing ideas such as the recognisability of the infrastructure in the neighbourhood and the choice of cyclists and pedestrians as the main form of traffic in the neighbourhood. Participants in the simulation in Emmen indicated, moreover, that some ideas that came up in the simulation are also useful for neighbourhoods that are being restructured in Emmen and for which decision-making is not at such an advanced stage.

Unlike in Emmen, the simulation game for the municipality of Alphen was not aimed at the generation of ideas immediately applicable to an existing restructuring project. The learning experiences with respect to sustainability therefore lie at another abstraction level: the interactive development of various visions of sustainability. If we compare the simulations in

Emmen and in Alphen, a clear distinction is apparent in the essential themes that came up in the simulation games.

The participants in both Emmen and Alphen indicate that the DuBes method is suitable for developing a good overview of the problems that are involved in a restructuring project, and for gaining new insights from different disciplines.

> *It is something of an open door, but sustainability encompasses much more than your own frame of reference. This offers you the opportunity to get to know other disciplines in your own field of work.*

In the written evaluation, about two thirds of the participants in both simulations indicated that they had gained a clearer picture of what sustainability can mean for the restructuring of a specific neighbourhood, of the decisions that need to be made, and of the various options for the restructuring of a neighbourhood. Over half the participants confirm that new insights and ideas for sustainable restructuring were brought up in the simulation game. Two thirds of the participants expect that the DuBes method will contribute to a more sustainable programme of requirements for the restructuring of a neighbourhood.

Table 1 Evaluation of the discussions in the working groups and planning studios based on the DuBes table during the game

	Emmen (n = 21)		Alphen (n= 25)	
M = average rising scale from 1-10 (SD = standard deviation)	*Session 1 (morning)*	*Session 2 (afternoon)*	*Session 1 (morning)*	*Session 2 (afternoon)*
1. To what extent was it possible to express your opinion in the discussion in your working group / planning studio?	7.88 (1.3)	7.75 (1.48)	7,7 (1,62)	7.7 (1.38)
2. To what extent does the DuBes table provide a good overview of the discussion?	7.64 (0.76)	7.29 (1.65)	7.7 (1.13)	7.7 (0.93)
3. To what extent do you expect the DuBes table will assist in the making of choices?	7.24 (1.51)	6.71 (1.55)	7.2 (1.2)	7.2 (1.38)
4. To what extent did aspects of sustainability play a role in the discussion in your working group / planning studio?	7.48 (1.42)	6.81 (1.86)	5.9 (1.83)	5.4 (1.64)

It is apparent from the evaluation of the discussion in the working groups and planning studios (see table 1) that the participants do not really think that aspects of sustainability played a great role during the discussion (see question 4, table 1). However, in this respect the simulation in Emmen scores better than the simulation game in Alphen. It seems that the participants from Alphen primarily applied a social vision of sustainability during the discussions, but assess sustainability primarily from an environmental perspective in the discussion. Among the participants in the Emmen game there were specialists in the field of energy, water, materials, ecology, etc. The participants in Alphen were especially managers and experts in the field of urban planning and housing. Despite the lack of expertise in some fields, in the final evaluation, the participants – also the ones from Alphen – indicate that they

have learned something about sustainability, about both the restructuring process and the problems and solutions for sustainable restructuring.

Even more than the essential results, the participants positively assessed the interactive aspect of the simulation (see questions 1 and 2 in table 1 in particular).

> *It is good to do this with all the different disciplines. We looked at matters that I would not have looked at otherwise, always from different perspectives.*
> *It helps to map out in a structured way the themes and decision fields that the parties involved find important.*
> *As a citizen/resident, you do not realise in how many areas decisions have to be made.*
> *It was good to hear the opinions of the experts who were present.*

4. CONCLUSION

Based on the experiences in Emmen and Alphen, the DuBes project will be continued along a number of paths. Firstly, the MEDIA model will be developed further so that the effects and costs of options and strategies can also be assessed. MEDIA will then be able to make a more prominent contribution to the discussion during the simulation game. Parallel to this, the DuBes simulation game will be played again a number of times for restructuring assignments. The results of the simulation game can serve as input for MEDIA. Secondly, the DuBes method will be applied to other types of construction projects, such as the development and construction of new residential estates and infrastructure, and the restructuring of business parks. Thirdly, the DuBes simulation game will be integrated into the educational syllabus of the faculties of Technology, Policy and Management, Civil Engineering and Architecture of the Delft University of Technology. The simulation game will be played with students from all three courses at the same time. In that way, students can learn in the course of their training that sustainable urban development is a task that they can only realise in cooperation with other disciplines and interested parties.

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Designing for Disassembly with Affordable Housing; Expositions and Practical Experiments for Sustainable Development

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1. INTRODUCTION

Within the diversity of complex issues embodied in the sustainability debate, one ongoing strand of activity is the development of ideas and practical actions which will assist the effective deconstruction and disposal of buildings and their component parts, either to facilitate modification/change of use or ultimately for disposal at the end of service life. Research sponsored by the Canadian Government's housing agency CMHC (Catalli,1998) suggested that there could be interest among homebuyers to incorporate Design for Disassembly (DFD) techniques as a feature of new home construction. It was argued, that in terms of the Canadian situation, DFD could represent a distinguishing feature for housebuilders within the marketplace.

This presentation will attempt to broaden the debate on what constitutes sustainable development in new housing with a specific focus on experimentation in the design and construction of housing incorporating both the facility to deconstruct and the establishment of protocols for the labelling of components and assemblies which will permit information required to facilitate safe disassembly to be embodied into their manufacture. One significant aim of the author's ongoing work is to evolve a system which can facilitate the transfer of information relating to assembly, disassembly and recycling of components between virtual models and their real world counterparts to benefit housing providers and users over whole life cycles for buildings.

The paper will draw on academic and construction industry experience in North America and the UK, including the author's past (Paterson,2000) and current experimental work. Principally, this aims to establish meaningful technologies for disassembly as a function of new housing design within a whole life perspective which address not just current market demands but also projected future needs.

2. PREAMBLE TO EXPOSITIONS AND PRACTICAL EXPERIMENTS

The broad context within which this paper is framed relates to the author's recent and current experience in teaching and learning with built environment undergraduates in the UK. As participants in "developed world" mindsets, cultures and behavioural patterns, we are under pressure at local, national and global levels to promote *sustainable design*, yet we are less clear what constitutes this imperative beyond paying lip service to principles and practice which may seem to have little impact on how our lives pan out in post-industrial societies where the pace of technological change seems exponential. As a paradigm for reflection, it could be noted that however worthy the idealism of the English Arts and Crafts movement in England during the late

19th century, the deference which William Morris and his followers paid to the retention of craft skills is recorded essentially as a strand of romanticism which had little practical effect in an environment where technology advanced with scant attention paid to the consequences of plundering natural and human resources for material gain. Similarly, one hundred years plus forward, the principle of sustainable design is a fragile concept which needs nurturing and articulating in tangible ways. These necessarily must have meaning and consequence for a largely technologically focused society to avoid degeneration into art form, exclusivity and demise. This is the challenge facing those involved in educating the next generation of built environment designers, viz to ensure meaning and consequence in translating expositions on sustainable design into practical actions and exemplars for teaching, learning and ultimately application.

3. EXPOSITIONS ON DESIGN FOR DISASSEMBLY

Crowther (2000) has proposed that action on the principle of environmental sustainability should necessarily take an holistic and whole life view of the consequences resulting from the design and use of buildings. Associated issues are diverse and form a broad spectrum and ranging from hard edged technical aspects of building design and construction to social issues relating to the use and reuse of facilities. One developing strand of activity has been the philosophy of design for disassembly which has seen an extension of interest and application from engineering and product design to architecture through the theoretical work of Crowther and others. Essentially, design for disassembly is based on the proposition that incorporating a methodology for dismantling a building at the end of useful service life into its design may make a meaningful contribution to *sustainability*. In terms of providing useable guidance for architects on design for disassembly, Crowther's advocacy of a performance based approach to sustainable design is reflected in his tripartite exposition of protocols based on addressing improved performance through articulating a hierarchy for disassembly and reuse based on:

Behavioural Statements – these propose gain through **reduction**, for example of

- Waste disposal and pollution
- Greenhouse gas production
- Energy consumption

Performance Standards – these propose gain through **increase**, for example of

- Material Recycling
- Component remanufacture
- Component reuse
- Building adaptability/relocatability

Prescriptive Guidelines – these propose gain through **guidance,** for example on

- Environmental benefits
- Technical benefits
- Chronological order of application

Catalli (1998) suggested that housing designers should consider the application of design for disassembly techniques as a function of facilitating whole life change. This approach suggests:

Strategic Actions - to be incorporated into the design process, inter alia

- Designing for versatility to allow components, assemblies or systems to accommodate change of function
- Utilising simplicity of design to reduce the complexity of assembling materials, thus facilitating disassembly
- Favouring independence of materials within assemblies to allow for minimum damage during maintenance, disassembly and removal
- Making significant labelling information explicit on each component or material of an assembly to assist with reuse or disposal after disassembly
- Exposure of mechanical connections where possible to facilitate disassembly
- Making materials or components with the shortest anticipated lifestyle most accessible

Design Drivers - applicable to the proposition and application of construction technologies for housing to facilitate layers of whole life change for maintenance, replacement, alteration or complete disassembly for relocation or disposal through

- The principal structure transferring dead and live loads to the foundation system to be demountable
- Internal partitions to be designed as independent of the principal structure
- External and internal finishes to be removable using hand or non-specialist power tools without significant component or material degradation
- Push fit or mechanical connectors for all services
- An assembly and disassembly rationale which facilitates progressive disassembly, in sequence of roof, internal partitions, floors, external walls and foundations.

4. PRACTICAL EXPERIMENTS

At the Robert Gordon University, we have been experimenting with design for disassembly techniques applicable to new housing since 1998. The principal aims of the experimentation have been to develop a series of prototypes which could

- Act as media to encourage students to investigate practical aspects of sustainable design and construction by engaging with the design and disassembly of full size physical models.
- Establish a developmental process through collaboration with UK construction companies to raise awareness of behavioural and performance standards applicable to sustainable design in a domain historically resistant to experimentation and associated risk to operational and fiscal targets
- Contribute to industry acceptance of the premise that the application of design for disassembly techniques to new housing does not necessarily present a barrier to change
- Instigate the formation of national guidelines for the application of design for disassembly techniques to encourage building designers to make informed and practical contributions to this component of the sustainability debate

Four prototypes have been developed to date in a series of experimental exercises labelled 4R6, 4R12, 4R18 and 4R24. The 4R6 and 4R12 have been written up elsewhere. (Paterson,2000)

4.1 4R18 Prototype

The prototype was designed in an academic exercise to investigate potential for applying design for disassembly principles and acted as a preamble to developing future proposals for a two storey demountable flat-packed home. This would follow Catalli's (1998) principles in the application of strategic actions acting as design drivers. The prototype was designed with provision of a floor area equivalent to a two apartment house with potential for future extension into the roof space. Plan layout was free from internal loadbearing partitions to facilitate maximum flexibility of internal layout at both lower and upper levels. The basic volume was enclosed by a linked portal frame arrangement forming a structural skeleton to receive wall and floor cladding. Each portal section was fabricated from flanges comprising stock sized 2.400x1.200m sheet of 9mm thick Oriented Strand Board (OSB) cut into sections and screwed to webs of Canadian Lumber Standard (CLS) softwood. Web sections alternated between solid and void on both X and Y axes to provide wayleaves for service runs.

Figure 1 4R18 prototype for flat-packed house designed for disassembly

Use of a consistent fixing screw size for the frame members resulted in a space enclosure formed by only three construction stock sized components in a configuration which facilitated non-complex assembly and progressive disassembly. The roof was formed by stock sized Structural Insulated Panels (SIPS) on a 4.800m long x 1.200m wide module with units interlocking and located with a hinged configuration at the ridge. Slates formed from recycled rubber could, typically, form the external weathering surface to the sloping roof planes. The insulating "skin" to external walls was provided by 2.400m high x 1.200m high SIPS. The SIP panels were specified to be constructed with faces of 9mm OSB bonded under pressure using a water based PVA adhesive a core of expanded polystyrene (EPS) or natural cork.

It is envisaged that evolution versions of this prototype will be constructed using physical and virtual formats working in tandem. The purpose of this next phase of development is to develop protocols for embedding labelling information on recycling and reuse into the components and assemblies forming the physical prototype using data storing microchip with radio frequency tags. These can be "read" remotely from the physical prototype and the stored information linked for identification and interrogation purposes to the virtual model which is constructed as a 3D graphical and alphanumeric database. Effectively, the virtual model would offer a set of instructions for disassembly and reuse which, in the case of an actual built project, could be read on site from the real world component or assembly using hand held radio frequency tracking equipment and a laptop computer. (Pearson, 2000)

Strategic Action	Example from Prototype	Comment
Design for versatility	Floor and wall frame elements potentially interchangeable	Good potential for reuse and/or material recycling. Reuse limited by potential damage during disassembly
Simplicity of design	Homogeneity of material for frame structure + wall/roof insulated envelope	Free plan facilitates wide range of changes to internal partitions without risk of damage or distress to primary structure. All frame elements stock items to minimise waste
Independence of materials	Frame assemblies formed out of "standard" sheet sizes of Oriented Strand board cut, and screwed together	Potential for ease of disassembly with frame materials. SIP roof and wall cladding can be delaminated and recycled through shredding for the timber composite and reprocessing for the EPS core component
Significant labelling	All components + assemblies	Requires application of sophisticated IT techniques to extract maximum potential
Exposure of mechanical Connections	All fixings to primary structure are exposed	Limited by variable user response to incorporating exposed fixings as an aesthetic for finishes
Accessibility of materials or components	Primary frame	All materials and components fixed to allow sequential disassembly for maintenance, relocation or recycling

Figure 2 Indicative audit of 4R18 against strategic actions for disassembly & reuse

4.2 4R24 Prototype

This experimental house was commissioned by a major UK housebuilder and was constructed in the North East of England in the autumn of 2000 as a market testing exercise in taking a corporate step towards incorporating a series of "sustainable design" imperatives into a volume built generic house type. The project provided the opportunity to build and analyse a full scale model of a three storey house and develop beyond the necessarily limited physical scale modelling associated with development of the 4R18 precursor. The superstructure was formed entirely in timber based closed panel wall, floor and roof elements which offered potential for progressive and complete disassembly for reuse or recycling. Formative work has been carried out on developing techniques for recycling the constituent elements of the closed panels. The exercise was constrained by the situation that the developer, while committed to moving forward with new technologies and construction techniques, required to market the house on completion and clad the prefabricated superstructure in a conventional brick outer skin with rendered finish.

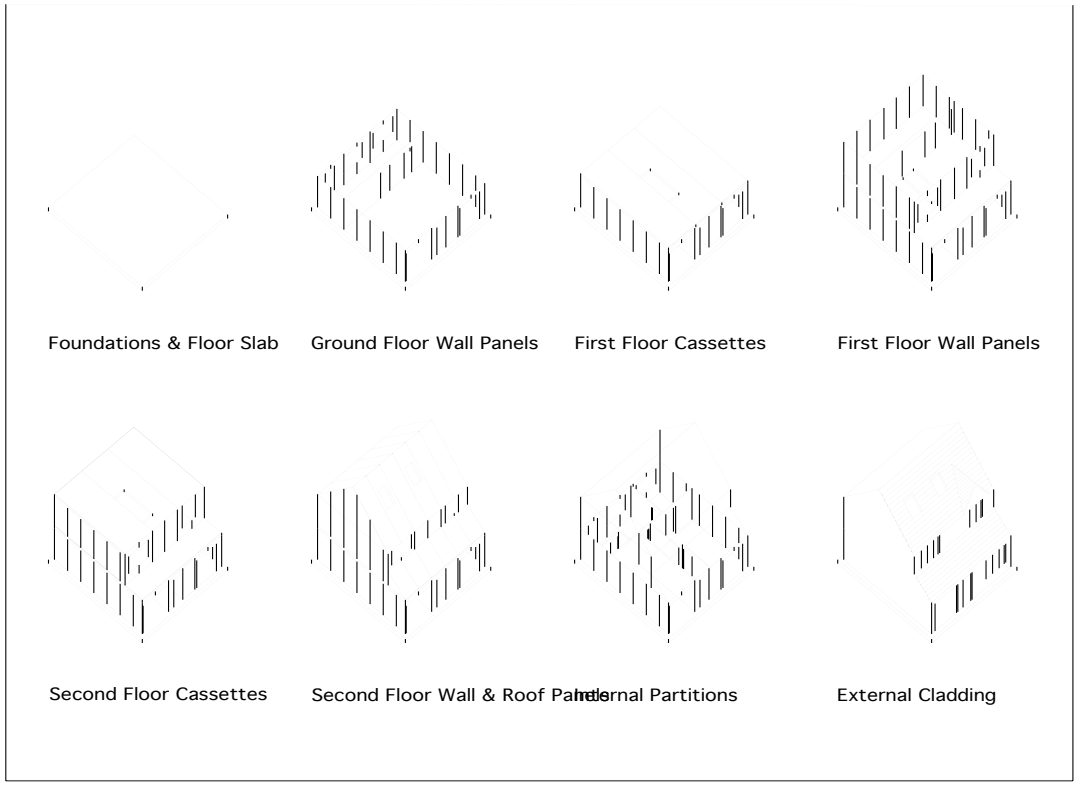

Figure 2 4R24 Prototype for three storey house designed for disassembly

5. CONCLUSIONS

New housing stock is perceived as being, by design, inherently resistant to change. Consideration of disassembly techniques should be embedded into the design process giving deference to whole life use at component, assembly and whole building levels. To progress these issues offers potential for new housing designed with improved performance characteristics in terms of user satisfaction and environmental gain. These actions translate into sustainable design.

Past and current work on design for disassembly in the built environment may largely be confined to academia. It is important that design for disassembly techniques evolve to enter the "hard edged" domain of commercial housebuilding through the framing of design guidance and ultimately national and pan-European standards.

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MEDIA. A decision support tool for urban development

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1. INTRODUCTION

The days that designers could focus on finding technical solutions for technical design challenges are past. Instead, they are confronted with increasing policy and design complexity, which is further enhanced if the concept of sustainable development (SD) is added to the equation. Urban (re)development, and large building projects in general, are design challenges where this trend is clearly visible. Decisionmakers in such projects, with ambitions regarding sustainable development, cannot ignore this increasing complexity. In order to realize technically and functionally sound projects that are acceptable to the actors involved and also comply with the principles of sustainable development, it is necessary that policy-makers, designers and SD-experts work together. Co-operation between these actors can be enhanced by tools that make design processes and decision making processes more transparent and offer insight in the impacts of decision options. So far, most tools focus on one of these three complexities described above, resulting in process-oriented tools, design tools, and analytical/technical tools, respectively. Although such tools generate useful information, integration is a challenge. The DuBes Sustainable Decision Making Project makes an attempt to provide an integrated approach for making sustainable decisions for an urban (re)development project. This project has so far resulted in two major products: the computer based conceptual modeling tool MEDIA (Modeling Environment for Design Impact Assessment) and a gaming exercise for sustainable decision making (cf. the paper by Van Bueren and Mayer in these conference proceedings). In this paper, the MEDIA and its conceptual and analytical foundations are presented, as well as the first results obtained by applying the model.

2. COMPLEXITY OF SUSTAINABLE URBAN (RE)DEVELOPMENT

An integrated approach to sustainable urban (re)development must do justice to these three types of complexity:

1. Content-oriented complexity, or the equivocal character of SD

Sustainable development and its derivative for the built environment, sustainable building, are concepts that are difficult to define. The most cited definition of sustainable development is the one found in the Brundtland report: “a development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). This definition was succeeded by principle 3 of the Rio Declaration on Environment and Development (UN, 1992): “to equitably meet developmental and environmental needs of present and future generation”. Both these definitions leave ample room for interpretation. When are present needs met? What exactly are the needs of future generations? How can we be sure we are not compromising their abilities? These questions cannot be answered

univocally and give SD its equivocal character. This equivocality manifests itself on philosophical, political and operational levels. All in all, it is fair to say that SD is a concept that should be further defined and negotiated in a political context.

2. Policy complexity
Large design challenges in the built environment typically involve a complex network of actors, who strive to achieve their ambitions and protect their interests (Marintz and Mayntz, 1991). This process is not governed by objective rationality, but determined by the perceptions and value systems of the actors involved, causing them to make competing assumptions about problems and solutions, means and ends, cause and effect. From the actor network perspective, there is no single correct view to policy problems and their solutions. Decisions are made in a complex process of negotiation between actors. The outcome of this interaction process is often sub-optimal in terms of both substantive quality and (public) support. The solution to this problem is sought in process management (De Bruijn and Ten Heuvelhof, 2000). This however does not make urban redevelopment projects themselves simpler.

3. Design complexity
Large building projects typically require of hundreds of major design decisions and many thousands of more detailed choices to be made. Decisions are often interdependent, and decision options may influence the values of multiple variables relevant for SD. Reductionist approaches to deal with this complexity tend towards mono-disciplinary models which, whilst scientifically valid, lack an overall picture of the problem in a societal context. More pragmatic and holistic approaches, on the other hand, are often not transparent and for that reason not acceptable for generic use. Others have described this as the dilemma of the choice between scientific disciplinary rigor and practical relevance. What needed is a balance between integration on one hand and scientific validity and precision on the other.

Together, the equivocality of SD, policy complexity and design complexity constitute a formidable barrier for an integrated and effective approach aimed at sustainable urban (re)development. The procedural rationality, typical of most model-based approaches, alone does not suffice for complex problems such as urban (re)development. An integrated approach must address each of the three complexities described earlier. MEDIA is proposed as a suitable underlying model for such an approach.

3. CONCEPTUAL FOUNDATIONS OF MEDIA

From the analyses that have been briefly described in section 2, these requirements can be drawn up: the structure of the model should be based on the physical decision making process; the model should adequately represent the policy complexity that is typical of urban (re)development; relationships between decisions should be included in the model; content related knowledge and insights regarding the consequences of decisions (e.g. costs, environmental impacts) should be linked to the relevant decisions; the model should not be normative with regard to SD-issues; the model should help the users focus on the most relevant issues only; the model should be able to function in a dynamic environment (e.g. a gaming exercise).

3.1 Addressing design complexity

To represent decisions and their interdependencies, Analysis of Interconnected Decision Areas (AIDA) has been used as a basis (Morgan, 1971). AIDA is a technique that makes large design challenges transparent and manageable. Design challenges are described as a set of decision areas, each with at least two mutually excluding decision options. Relations between

decision areas and decision options can be formalized, creating transparency and insight in the direct and indirect consequences of one specific decision or a comprehensive set of decisions (scenario). In figure 1, three typical decision areas and their options are presented as an example. Two types of relations exist: exclusions between options of different decision areas and preclusions between a decision option and other decision area(s). These relationships can be definite, probable or possible.

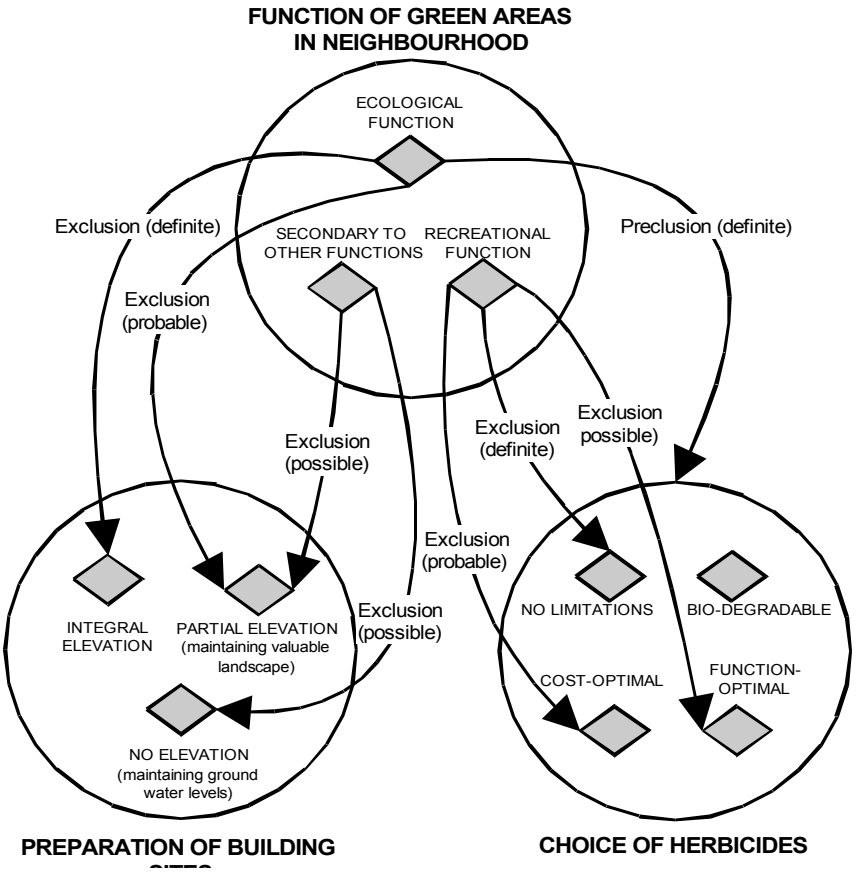

Figure 1: Interconnected decision areas

The AIDA concept has been implemented in MEDIA, without any major conceptual changes. Based on several case studies, currently over 200 major decision areas have been distinguished for a typical urban redevelopment case. To maintain overview, the concept 'Theme' has been implemented in MEDIA. Themes are categories of decision areas related to the same topic.

3.2 Addressing the equivocality of SD

The problem of the equivocality of SD is hard to solve conceptually. Any attempt to develop a generic set of indicators and calculation models can be regarded as "yet another interpretation" of this concept. To deal with this problem, MEDIA has been designed as flexible as possible. MEDIA is not conceptually based on any single definition or model of sustainability, but structured in such a way that different definitions can be facilitated. The model can accommodate different types of data and models. In figure 2, this flexibility is presented with an example from practice. Direct impacts of options are expressed as descriptive variables, which can directly or through the use (complex) functions be used for defining SD-indicators.

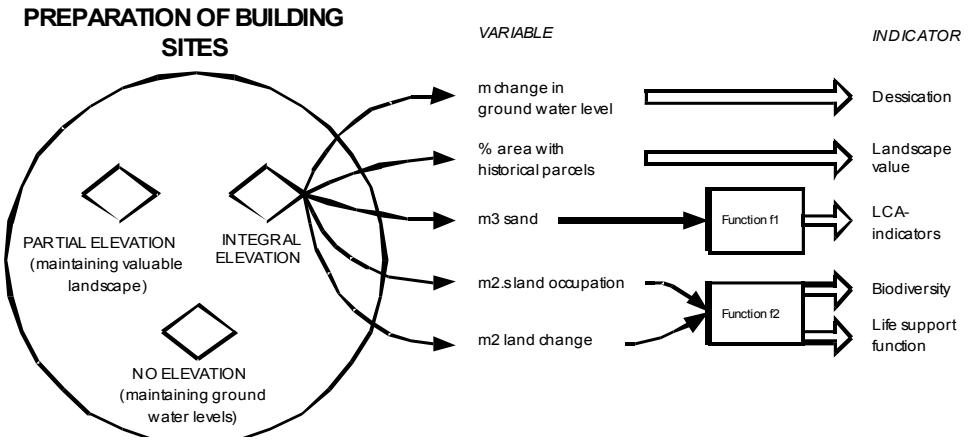

Figure 2 Flexible multimodel structure

This flexible structure may seem indecisive, but the benefits (no approaches are precluded or forced upon actors, and dialogue between actors is facilitated) outweigh the drawbacks (no 'easy' answers are provided).

3.3 Addressing policy complexity

Differences in actor perceptions are a main driver of policy complexity, and actor network analysis provides concepts to deal with this complexity: Actor perceptions are made explicit in a conceptual language, making different types of comparative analysis possible. By doing this, the analyst sharpens her insight not only in the policy situation at hand, but also in her own reasoning. In figure 3, the implementation of actor network concepts in MEDIA in presented, with an example.

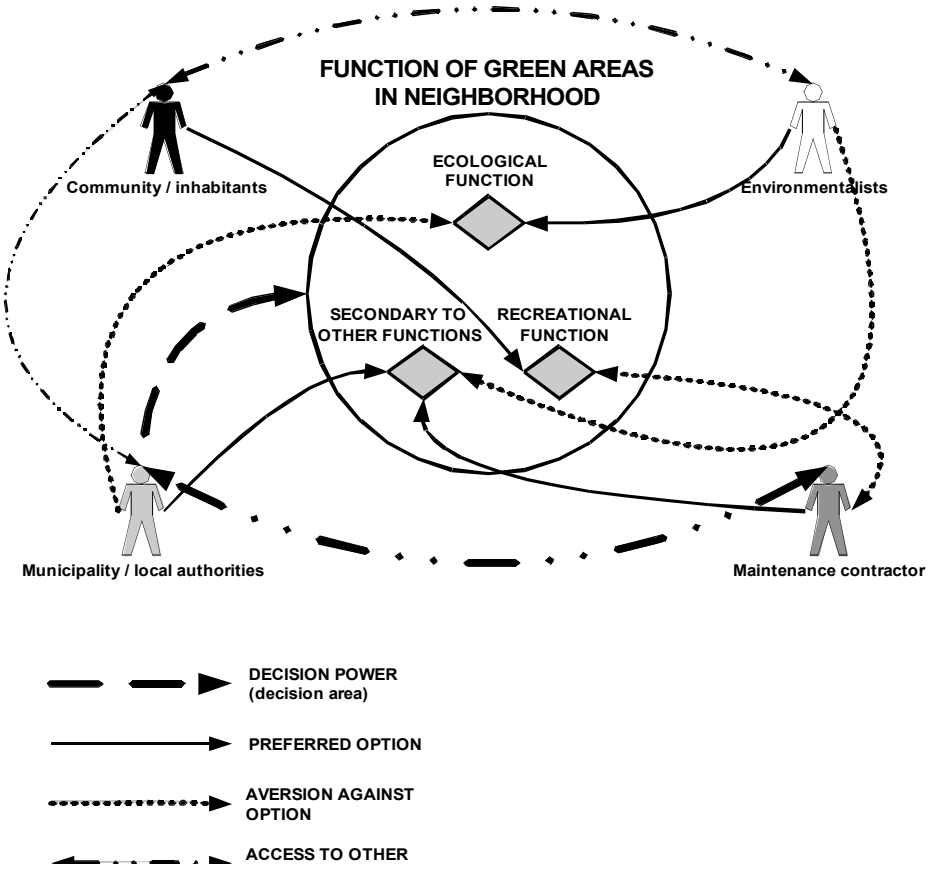

Figure 3 Conceptual foundations: dynamic actor analysis

Several functions in MEDIA represent the concept actor network analysis. First, each separate actor can be described. Second, the decision power of each actor can be formalized, as well as their preferences and aversions for separate options. Finally, the relations between actors can be formalized

In figure 4 a screenshot of the most relevant menus of MEDIA is presented. Top left is the menu in which decision areas, decision options and variables (impacts) are defined. Top right shows the menu in which preclusions and exclusions are specified. The relations between decisions, options and actors are defined in the down left menu. In the final menu, the agenda is presented. The agenda is used in the gaming exercise, were it helps the users to focus on the most relevant decisions.

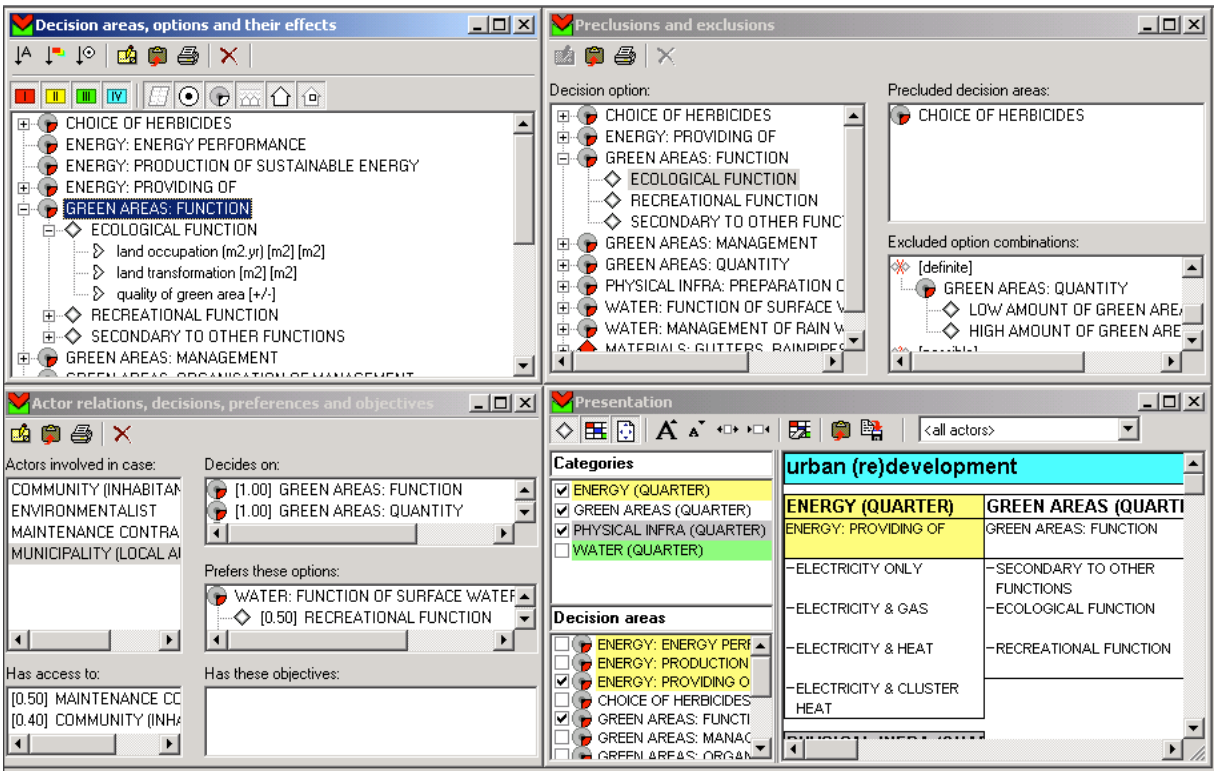

Figure 4 MEDIA interface

4. RESULTS AND OUTCOMES

The results of working with MEDIA can be divided in two. First, the model has been used stand-alone for the modeling of a number of cases. Second, MEDIA has been used as a supportive tool in the gaming exercise twice. The results of these exercises are briefly discussed below.

MEDIA has been used for the modeling of a urban redevelopment project of a typical Dutch post-war residential area. The definition of decision areas, decision options, variables, preclusions and exclusion has turned out to be both possible and useful, since it forced the user to look at the project in a systematic and consistent manner. Altogether, about 200 decision areas have been distinguished. Most decision areas relate to the quarter and building-level. The decision areas are categorized into 30 themes. In addition to defining themes, decision areas and options, variables have been attributed to some of the decision options.

Almost no values of variables (data) have been added to the database, as this proved to be very time consuming, since a lot of data is unavailable, or not available on the level of aggregation needed for MEDIA. The implication of the limited amount of data is that MEDIA at the moment is not able to assess the SD-impacts of scenarios. More consistency and completeness was achieved in the definition of preclusions and exclusions. A total of 438 of preclusions and exclusions have been distinguished, mostly exclusions. As far as actors and their relationships concerned: because of the very case-specific character, this feature has not been the focal point of our efforts. The aggregation of decision areas and options to the level of a coherent design turned out to be possible, but still needs further development in order to be useful.

MEDIA has also been used as a supportive tool in two gaming exercises. For this purpose, a paper version of the model, containing only themes, decision areas and options was used, as well as the agenda-function of the computer version. In this form, MEDIA served mainly a communicative, educative and informative purpose. No assessments could be performed. Since the gaming exercises were developed for the early stages of a project, in which there is less need for evaluation, this posed no real problems. The lack of assessment functionality was perceived by the players as a shortcoming of MEDIA, especially if the model is to be used in design stages.

5. CONCLUSIONS

If the results of working with MEDIA are analyzed, it can be concluded that the model with its current functionality facilitates the early stages in a project (initiative and programming) much better then later stages (design and realization). For these early stages the model can, in combination with the gaming exercise, play an important communicative, educative and informative role.

For the later stages of urban redevelopment projects the model currently lacks the finesse to model and visualize actual designs. Also, the lack of data and the subsequent inadequate assessment functions of the current model, limit its application to the early stages of projects. Future research is therefore expected to focus on these two main shortcomings

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Combining Theory with Practice: the Development of the QUT Centre for Smart and Sustainable Construction

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1. INTRODUCTION

The commercial building industry in Australia is facing a dilemma. While there have been ever increasing technology innovations and sustainable solutions, in everyday decision-making, it still comes down to an economic decision for many stakeholders. Low development costs seem to outweigh all social, technical, behavioural, environmental, regional and political considerations. Over the years, adaptations of sustainable and intelligent building technologies have been on an ad hoc basis in new buildings. But they do not present the 'whole picture' as viable alternatives to stakeholders. Moreover, the commercial building sector has an increasing pressure to respond to emerging issues such as the environment, resource reserves, and changing business operating patterns.

This paper reports on the development processes of the Centre for Smart and Sustainable Construction (CSSC) at the Queensland University of Technology (QUT), Australia. The Centre is being developed to remedy the above situation by incorporating research development with a living laboratory as demonstration and application facility. It further tests the idea of "combining theory with practice" by providing practical space usage with testing and experimentation, teaching and research with industry collaboration, and international scholarly activities with community service. This paper highlights the emerging issues in building construction and the gap between innovation and implementation. It introduces the Centre's initiation and development with particular discussions on its major elements, unique characteristics and directions of on-going development.

2. EMERGING ISSUES IN BUILDING CONSTRUCTION

2.1 Environmental concerns

Australia has an international image of being a safe, green and 'eco-friendly' country. However due to reasons particular to Australian characteristics including widespread land clearing for urban development, Australia is the one of the worst greenhouse polluting countries. The emission of greenhouse gases is considered a major issue with significant impact to the global climate change, the environment and resource consumption. Australia recognizes the challenge and has plans to participate in the Kyoto Protocol with a key target to reduce gas emissions to no more than 8% by 2010 compared to the level in 1990 (AGO 1998). As illustrated in Figure 1, the commercial building sector in Australia is a major contributor to energy consumption and CO2 emissions. A wide range of construction activities from new building construction, through retro-fitting, services provision, to maintenance and operation of building facilities and systems, and use of building materials and products, construction processes and service all contribute to the greenhouse gas emissions directly or indirectly through energy consumption economy (Tucker and Treloar

1994). The challenge is therefore to make a quantum leap in the overall package of designing, developing and constructing buildings that embody better environmental performance.

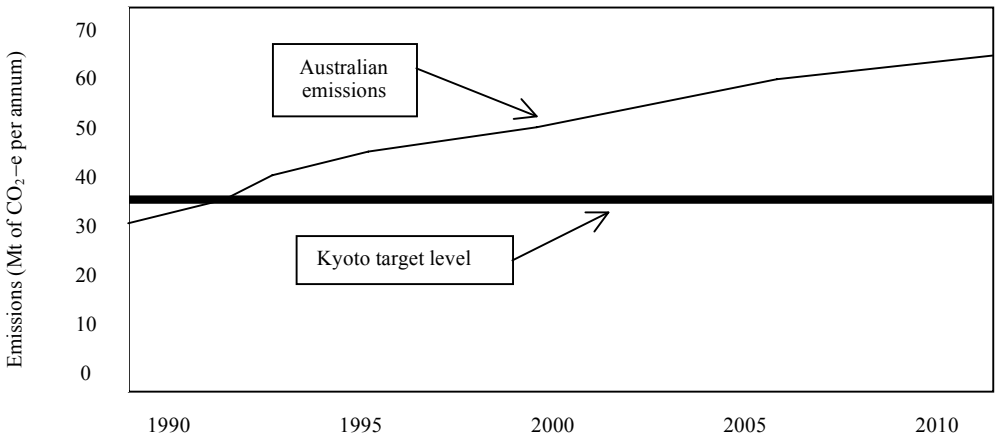

Figure 1. Australian commercial buildings greenhouse gas emission (source: AGO 1998)

2.2 Changing business operating patterns

The design, construction, operation and management of office buildings need to respond to three new business requirement and operating patterns of corporate clients as follows:

- Large corporate clients of commercial buildings, such as those in finance and telecommunication, increasingly do not provide individual office space for every staff member on a given day, recognizing that many may be out with clients or on travel. Instead, just-in-time offices, team workspace and special assignment space are promoted.
- Many businesses reorganize frequently in response to changing client needs and market opportunities. Churn rates, the frequency of office and facility relocation, and associated costs are among some of the major items considered for operational efficiency.
- Advancement of telecommunication technologies is reshaping the way business is carried out. Professional accounting, for example, may require the 'perfect office' typically equipped with a range of new IT and peripheral systems (Zarowin 1999), thus placing new building requirements for accommodating and upgrading these systems.

2.3 Re-emphasis on human needs

For commercial buildings, there is a renewed emphasis on human needs for better work conditions and individual comfort. Workplaces should offer occupants individually controlled and ambient HVAC and lighting systems, flexible connected data and power management, as well as responsive office partitioning with changeable functionality (Loftness, et al 1997). This will increase employee satisfaction, improve work performance, and reduce staff downtime thus achieve cost savings (Bauman, 1999).

2.4 Innovation challenge and building performance

Compared to their counterparts in Europe, Japan and the USA, the Australian building industry is lacking stimulant for R&D and needing "live" integrated projects to promote technology innovation and commercialization. As building performance is much influenced by the building's envelope, services and occupants and their behaviour, the most effective time of ensuring a high performance building is during its pre-design stage of development, where alternatives, strategies and decisions can be identified and established.

3. THE GAP BETWEEN TECHNOLOGY ADVANCEMENT AND APPLICATIONS

A range of innovative technologies and products are being developed to enable smart and sustainable development of commercial buildings (Mawson, 1994, Cho and Fellow 2000). For example, there are specific, "tactic" technology inventions such as new window glazing systems and access floors (York, 1992). There are also general, "strategic" systems such as the concept of Green Buildings and Intelligent Buildings (Dewer and Gann, 1994).

Despite the advancement, there is a current gap between available new technologies and the level of their implementation, particularly in Australia. Possible reasons may include the lack of information and understanding of smart buildings among owners and developers of commercial buildings, the least cost mentality of project stakeholders, and the general lack of experience thus willingness to adopt such innovations by architects, engineers and contractors. The crux of the issue however, is the lack of demonstration projects that will act as worked examples and role models as being the viable alterative. As a result, commercial buildings are continuously being constructed using conventional and non-sustainable technologies while new building materials and products are ready for applications.

4. DEVELOPING THE QUT CENTRE FOR SUSTAINABLE AND SMART CONSTRUCTION

4.1 The QUT Centre

QUT's Centre for Smart and Sustainable Construction is developed to rectify some of the above problems. It aims to promote the Australian development of the advanced sustainability principles in the design, construction management, and maintenance of commercial buildings by actively incorporating research, teaching, industry collaboration and community service into a "test-bed" environment while offering real-time operation of a multi-functional building facility. The Centre will be housed in an innovative physical structure at the rooftop of a new building at the Gardens Point Campus of QUT in Brisbane, Australia. The entire space will be integrated into the experimental nature of the Centre while being used as offices, meeting rooms, lecture theatres, plant rooms and laboratories. Figure 2 illustrates an architect's impression of the Centre as a building extension.

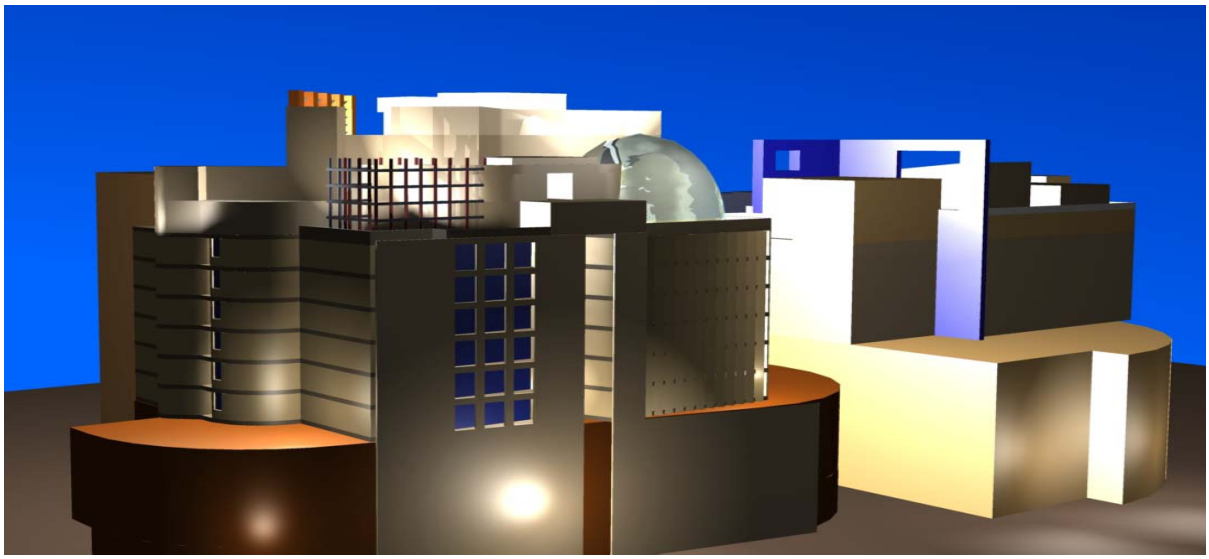

Figure 2. Architect's impressions of the QUT Centre for Smart and Sustainable Construction (Source: CSSC feasibility study in 2001 by QUT/Arkhefield)

4.2 Other centres and initiatives around the world

In initiating the QUT centre, other centres and initiatives in the world for sustainable construction have been identified and studied.

In the USA, the Centre for Building Performance and Diagnostics (CBPD) in Carnegie Mellon University has established the Intelligent Workplace, focusing on the performance of new building designs and products in an occupied setting. The General Services Administration (GSA) partnered with the CBPD to set up the Adaptable Workplace Laboratory in Washington DC to study the impact of technologies on employee productivity and organizational behaviour. The "Green Building", head-office of the Department of Environmental Protection, Pennsylvania, provides a real life example of incorporating sustainability principles into the conception and design of commercial building development. In the UK, energy concerns have fostered new approaches to mechanical servicing in the design of offices buildings. Various examples can be found in high-profile low-energy, passively ventilated buildings in which architectural forms purposely express the function of passive ventilation such as chimney-like solar stacks, allowing fresh air to be introduced at the bottom of a space for more effective ventilation. The European project of Bo01 City of Tomorrow embeds many sustainability and environment focuses such as the Sustainabuilding, European village, and the Energy Factory to exhibit and promote environmentally friendly construction concepts. In Hong Kong, the Building, Land and Planning Department of the local government has issued guidelines on green features of new building development such as facades, wind catchers and funnels and relevant incentives for developers and contractors to incorporate these features.

While these centres and initiatives are very successful in exploring innovative designs, new materials, development themes and legislations, they provide solutions to individual problems, rather than the integration of materials, systems and processes for sustainable and smart building solutions. The CSSC at QUT aims to address this vital issue with a live demonstration facility. The strategic location of the QUT Centre in Brisbane, with typical sub-tropical climate, resembled by many other counties in the Asia Pacific region, will develop technologies applicable to the particular environmental constraints in Australia and other countries.

5. MAJOR ELEMENTS OF THE QUT CENTRE

As the first Centre of its kind in Australia, the QUT Centre needs to provide leadership in research and innovation in construction efficiency and environmental sustainability. It hopes to achieve its role through incorporating and operation of several major elements.

5.1 Research and teaching

Taking advantage of the unique nature of multi-disciplines of the Faculty of Built Environment and Engineering at QUT, the CSSC will foster collaborative research projects across disciplines at QUT and with the industry. It will include:

- Development and incorporation of intelligent and sustainable building design, materials, and technologies including building performance based research.
- A unique research focus on the processes of developing smart and sustainable commercial buildings considering design-in concept, effective coordination between project stakeholders, rational, rather than ad-hoc, installation and construction processes, waste minimization and procedures of efficient facility management.
- Specific emphasis on retro-fitting and upgrade of building systems, services and facilities

- Considerations of "whole of life" costs of building development and operations.
- Innovative undergraduate and postgraduate courses in areas of building services engineering, intelligent building and facility management, to allow students across the university to make direct contact with energy efficiency and sustainability practice.
- Learning in a *Living Laboratory* where students, staff and industry can experiment and experience new ideas in a seamless integration between teaching, research facility and real workspace in plant rooms, system consoles, underfloor plenums and building façade.

Having considered initial reactions and support from the university community and the industry, the QUT Centre has established the following integrated areas as major research themes: (*A) Innovative Building Systems and Technology; (B) High Performance Building Products; (C) Sustainable Energy Use; (D) Smart and Healthy Workplace; and (E)Sustainable Development Processes.*

Under these themes, a range of specific research topics are developed and explored from cross-disciplinary perspectives such has: retrofit technology using raised floors and associated technologies; waste water treatment; renewable energy - PV cells, wind generators; energy management and lighting control; indoor air quality enhancement; decision support to design and procurement processes, lifecycle costing and feasibility analysis, facility management and environmental planning; and changing building legislation and regulatory issues in lieu of sustainable development.

5.2 Industry collaboration and community service

The Centre also has aims to work closely with the industry and community in providing research expertise for R&D and/or consultancy work. The themes developed to date include:

- Joint research with design consultants, materials suppliers, building system vendors utilizing QUT's specialist experts, the Centre's facilities and testing equipment in an incubator environment.
- Industry's association with and contribution to the education of future professionals in existing and new undergraduate and postgraduate courses.
- "Showcase" of industry's latest development in independent university environment.
- Community education through facilitating visits from government agencies, community and local schools groups.
- Professional leadership in ecological sustainability of the built environment through consultancy, seminars and training workshops.

5.3 Laboratory and workspace

The "living laboratory" concept integrates research facilities with the practical use of workspace. In additional to research labs and lecture theatres, offices at the Centre will reflect the hallmarks of a productive workplace: spatial equity, healthy environment, flexibility, thermal/lighting/acoustic comfort, technological connectivity, reliability and a sense of place.

5.4 Strategic Alliances

The QUT Centre has plans to establish strategic alliance with two partner groups. The first is the industry partner group comprising corporate clients (owners, developers and tenants), building material suppliers, IT providers, building system vendors, architectural and engineering consultants, and contractors.

The second is the research partner group comprising universities, research institutions and government agencies around the world utilizing linkages to organizations such as the

Australian Building Energy Council, relevant Working Commissions of CIB, and CBPD at Carnegie Mellon University.

5.5 Significance of the QUT Centre

The QUT Centre will advance QUT, the construction industry and national interests of Australia through: (1) cross-disciplinary research opportunities and collaboration among academics in other Schools, Faculties within QUT and in other universities domestically and internationally; (2) potential to maximize QUT's research return through commercialization; (3) enhancement of the Australian building industry's opportunities by developing comprehensive and practical solutions in independent environment; (4) fostering industry-university linkages for the long term benefits of students, staff and industry partners; (5) visions and strategies for the Australian development of sustainability issues; (6) provision of timely responses to emerging challenges in relation to business operations, environmental concerns and people's need; and (7) providing a vital link between the industry, the community and the world in regards to sustainable construction.

6. ON-GOING DEVLOPMENT OF THE QUT CENTRE

The conception of the QUT Centre can be traced back to 1999 and 2000 when the authors conducted research work in construction innovation and study visits to many USA, UK and European projects on building performance, sustainability and the environment. This culminated in the overall development proposal of the CSSC. Following initial investigations, a working party on the Centre was established in 2001, comprising academic representatives from all Schools of the Faculty of Built Environment and Engineering, representatives from the industry, other Faculties and administrative areas of QUT. Cross-disciplinary discussions followed leading to the establishment of research directions and themes. University level meetings with QUT's top management and QUT Development Office have resulted in the commissioning of a feasibility study of the physical development of the Centre. To date, CSSC's development has gone through the conception, feasibility and design stages with the physical construction work being contemplated in coincidence with QUT's campus redevelopment scheme, involving independent architectural, services and engineering consultants. Work to date has produced executive strategies and policies, a full feasibility report, design consultations and decisions, and a handbook for ongoing development. Next stages of work will establish research teams in anticipation of the construction development of CSSC and working with industry partners to complete its physical elements.

7. CONCLUSION

The study of many existing overseas centres and initiatives for sustainable construction has revealed inadequacies evidenced by the lack of a holistic approach to complex issues of sustainability. A "living laboratory" can experiment and address the issues between products, services, processes and people in a seamless manner. Australia, as an advanced country with a mild and friendly international image, has a leading role to play in environmental and sustainable affairs in the world. The QUT Centre in Brisbane has a geographical advantage and typical sub-tropical climate similar to many Asia Pacific, African and South American countries, which are placing or will place major emphasis on environment and energy consumption issues. The QUT Centre can help contribute to Australia's leading role by developing strategies and technologies in sustainable construction that are adaptable and appropriate to these countries. Domestically, Australia's high energy consumption per capita, increasing construction activities, and the aging stock of commercial buildings demand timely and innovative solutions to better building performance. Research centres such as the CSSC, can combine theoretical research and experimentation with the practical operation of

workspace to incubate higher level and industry wide application of smart and sustainable construction technologies.

8. ACKKNOWLEDGEMENT
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Tracking Sustainable Benefits: Municipal Projects by the City of Seattle

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1. INTRODUCTION

In response to growing concern about the environmental impacts resulting from where we build and what we build, the City of Seattle recently led a regional task force towards developing a Sustainable Building Action Plan. One element of the plan was to lead by demonstration, and in 1999 the City of Seattle adopted policy which directed City-funded, occupied projects over 5,000 square feet to achieve a Silver Rating from the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Version 2.0 Rating System.

In order to identify successful strategies for replication, and to use performance and cost in the definition of that success, an evaluation framework has been developed. Called the City of Seattle LEED Evaluation Plan, it includes an overview of the design process, tools for project managers to use in identifying and collecting data, and suggestions for ongoing measurement of building performance. This information can then tracked by the Office of Sustainability and Environment (OSE) to refine the building procurement process and to present results to the Seattle Mayor, City Council and other decision makers.

1.1 Seattle LEED Evaluation Plan

Section 1 Provides and overall introduction to the Evaluation Plan and the benefits that are at stake.

Section 2 Discusses the Design Process from a whole building perspective. Building performance, design integration and prediction tools are presented. Modifications to conventional practice are identified.

Section 3 Presents the City capital facilities project manager with a Tool Kit to collect prediction data made by the design team, along with the proposed designs that produce long-term benefits. A data collection roadmap for the project manager is provided along with documents used to capture the information in. (The Tool Kit includes a Project Information Form, the LEED Rating System with Seattle Supplements, a LEED Template and Calculator and a Measurement and Verification Schedule.)

Section 4 Presents Project Tracking Results of the first round of data collection and analysis of the cost and benefits of City projects pursuing a LEED rating. Aggregate benefits are provided in a summary sheet, along with details for selected environmental areas.

Section 5 Discusses the issues around benchmark data that will be used for comparison. There are a variety of data sets that can be used with strengths and weaknesses.

Section 6 Provides Conclusions and Recommendations on how to move towards a fully operational Sustainable Building Evaluation Plan.

1.2 The Benefits of Sustainable Building Performance

The benefits of optimal building operation, especially in terms of energy and water performance, are substantial because the lifetime of many buildings is greater than 50 years. Even minor energy and water savings are significant when considered in aggregate. These long-term benefits can be unrealized due to poor maintenance, personnel changes, aging of building equipment, and changing utility rate structures. Therefore, it is important to institute measurement & verification (M&V) procedures, or periodic checkups, to maintain optimal performance over the lifetime of the building.

1.2.1 Environmental Benefits. Measurement and verification of a building's ongoing energy and water consumption allows for optimization of related systems over the lifetime of the building. As a result, the environmental impacts associated with energy and water use can be minimized, including air pollution, water pollution, and natural resource depletion.

Seattle is a key stakeholder in the effort to halt declines in our local salmon fisheries. By better understanding how our commercial building stock contributes to stormwater for example, the City can then change roof designs to minimize stormwater surges during peak rainy periods.

1.2.2 Economic Benefits. Optimization of building energy, water and materials systems not only has the potential to reduce the environmental impact of Seattle's new building portfolio, but decrease operational costs as well. The added cost to institute a rigorous evaluation program for ongoing measurement is 1% to 10% of the total building cost, depending on the nature and scope of the approach. These additional first costs can often be repaid within a few months to a few years of operation due to energy and water utility savings as well as reduced operations and maintenance costs.

1.2.3 Community Benefits. The collateral benefits of energy and water efficiency to the community are often diffuse and difficult to quantify over time. However, a healthy work force and a healthy ecosystem are both indicators of a long-term pattern of sustainable development. Continuous measurement of resource use at individual projects will aggregate and provide benefits to the community over several generations, extending the resource base they enjoy and depend upon. Alternative transportation features that encourage City employees to walk, bus and bike to work can reduce stress from commuting on our congested streets, and improve people's health at the same time.

2. SUSTAINABLE DESIGN PROCESS

The Evaluation Plan provides a framework for the Sustainable Building Design Process for City of Seattle building projects. The Process is designed to track sustainable measures that are incorporated into buildings and assess the effectiveness of these measures.

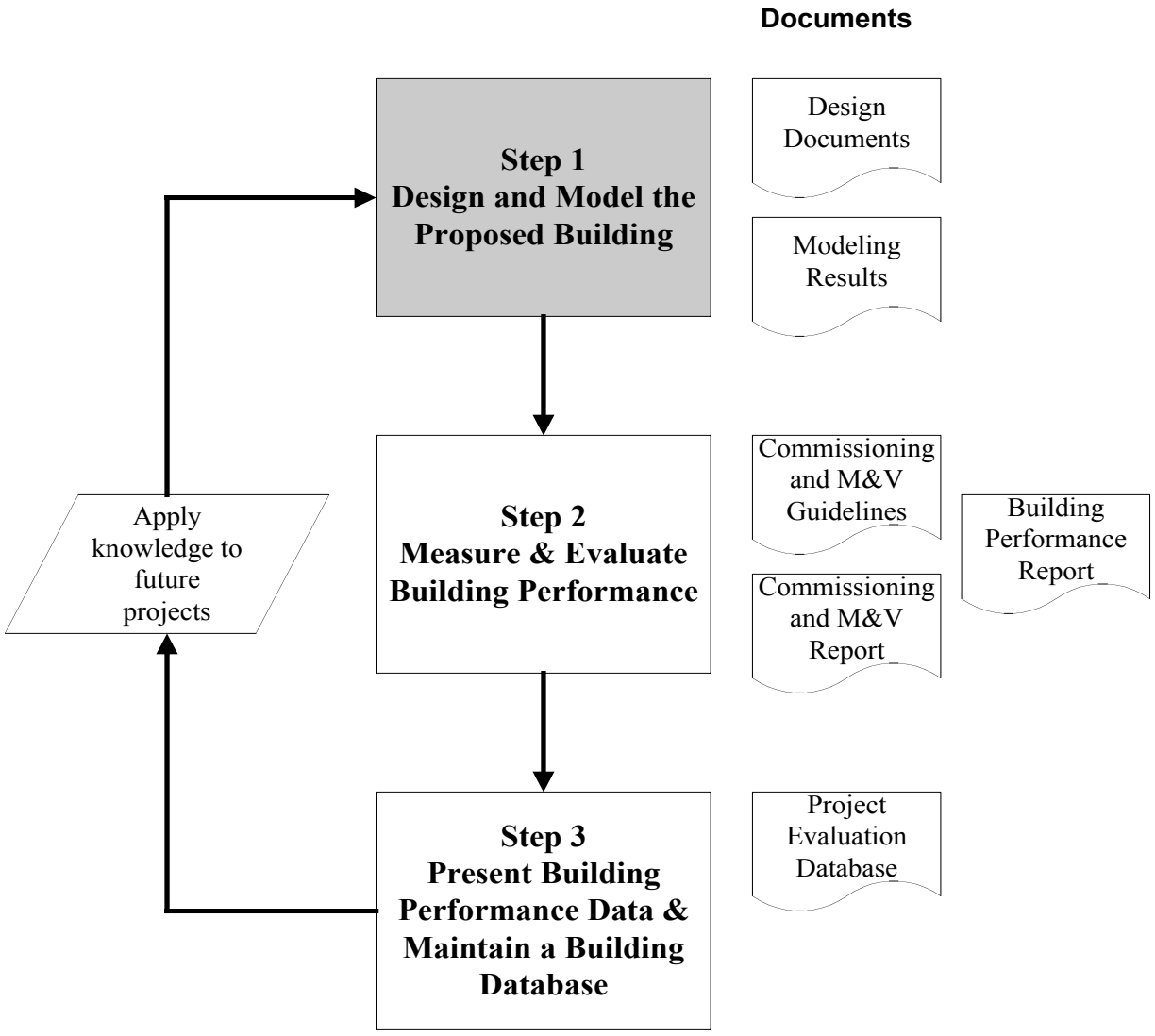

Figure 1 Sustainable Building Design Process

The three steps shown in Figure 1 illustrate the Sustainable Building Design Process. Initially, the proposed building is designed and modeled. The Seattle project manager provided with a Seattle LEED Packet by the OSE, that includes the Seattle LEED™ Supplements, a Seattle LEED Tracking Form, and an Measurement & Verification (M&V) Schedule. The project manager creates a preliminary list of LEED credits for the project and assembles the consultant team with the skill set required. The project manager will coordinate with the OSE and the commissioning

agent for the project to determine a methodology for M&V. Documents produced by this step include design documents, and modeling results.

The second step of the process is to measure and evaluate the performance of the building for several parameters. These parameters might include energy use, water use, indoor air quality, and other environmental factors. Documents produced during this step include Commissioning and Measurement & Verification Guidelines, a report summarizing the findings of Commissioning and Measurement & Verification activities, and an overall Building Performance Report.

The final step in the process is to present the findings of the Building Performance Report to the Seattle City Council, City of Seattle Design Teams, and building occupants. Performance review of sustainable measures is important to determine which measures are valuable and which should not be considered for future projects. Building performance data will be maintained in a database.

Lessons learned from the building performance data will be fed back into the first step, the design and modeling portion of the process. Thus, a cyclical design process is put into practice where knowledge gained from existing buildings is applied to the design of new buildings. For instance, a water reuse strategy may prove to be overly costly due to an underestimate of annual maintenance costs. Conversely, inclusion of carbon dioxide sensors may improve indoor air quality and increase building occupant productivity to a greater extent than predicted in design models.

3. TRACKING SEATTLE LEED PROJECTS

Table 1 Summary of Estimated Savings

Summary of Savings

Project Name	Waste Mgt [$]	Stormwater [$/Yr]	Energy [$/Yr]	Potable Water [$/Yr]	Wastewater [$/Yr]	Equivalent Productivity Savings [$/Yr]
Seattle Justice Center	$6,188	$1,145	$54,000	$796	$1,808	$800,00
Seattle City Hall	$4,084	$2,466	$35,640	$2,046	$1,876	$830,00
SW Precinct	$619	$4,282	$5,400	$422	$249	$110,00
Key Tower Remodel	$12,788	$5,140	$223,200	$3,097	$9,098	$4,026,00
Park 90/5 Building C	$3,754	$10,678	$32,760	$1,061	$723	$320,00
McCaw Performance Hall	$27,500	$8,140	$53,100	$1,054	$2,616	$6,000
Fisher Festival Pavilion	$495	$1,480	$4,320	$812	$1,858	$0
Cedar River Treatment Facility	$74	$951	$864	$227	$36	$6,000
Northgate Community Center	$413	Data being collected	$3,600	Data being collected	Data being collected	Data being collecte
Central Library	$8,539	$4,427	$74,520	$552	$1,035	$157,00
North Cascades ELC	$480	$2,112	$5,580	$263	$68	$15,00
Yesler Community Center	$413	Data being collected	$3,600	$379	$466	$6,000
Combined Training Center	$1,134	Data being collected	$9,900	Data being collected	Data being collected	Data being collecte
Total Annual Savings	$66,478	$40,822	$506,484	$10,709	$19,832	$6,276,000
% Saved Over Conventional Building	31%	25%	24%	16%	20%	2%
Total Annual Quantities Saved over Conventional Building	1,662 tons	3,668,030 gal/yr	10,130 mWh/yr	3,137,906 gal/yr	2,858,257 gal/yr	$6,276,000 $/yr

The City is currently tracking multiple projects that are pursuing a LEED rating of Silver or higher. In order to share information with future projects and assess the benefits of sustainability, a project tracking system has been developed. The following tables summarize which LEED credits are being pursued by the projects along with benefits associated with specific environmental areas. Savings data presented in the supporting tables is currently estimated, based on the LEED calculator and performance targets set by each project. As the projects are occupied, Facilities Maintenance personnel at each project will compile actual savings data and provide it to the Office of Sustainability and Environment. The actual savings data will be used to update the savings tables so a more accurate picture of the benefits of sustainability can be presented.

Table 2 Summary of Construction Cost and Payback Periods for Seattle LEED Projects

Summary of Project Budget and Savings

Project Name	Project Construction Cost	Estimated First Cost Add [%]	First Cost Add [$]*	Total Yearly Savings from LEED Silver	Payback [Yrs]	Net Present Value [30 Yrs]
Seattle Justice Center	$92,000,000	4%	$3,680,000	$857,749	4.3	$8,126,765
Seattle City Hall	$72,000,000	4%	$2,880,000	$872,028	3.3	$9,123,323
SW Precinct	$13,000,000	6%	$780,000	$120,352	6.5	$876,621
Key Tower Remodel	$28,000,000	0%	$0	$4,266,535	0.0	$58,728,138
Park 90/5 Building C	$18,000,000	0%	$0	$365,223	0.0	$5,027,229
McCaw Performance Hall	$125,000,000	1%	$1,250,000	$70,910	17.6	-$273,940
Fisher Festival Pavilion	$8,530,000	Being Collected	---	$8,470	---	---
Cedar River Treatment Facility	$76,000,000	Being Collected	---	$8,079	---	---
Northgate Community Center	Data being collected	Being Collected	---	$3,600	---	---
Central Library	$161,000,000	2%	$3,220,000	$237,534	13.6	$49,622
North Cascades ELC	$15,000,000	Being Collected	---	$23,023	---	---
Yesler Community Center	$7,000,000	Being Collected	---	$10,444	---	---
Combined Training Center	$16,000,000	Being Collected	---	$9,900	---	---
Total Portfolio	**$631,530,000**		**$11,810,000**	**$6,853,847**		**$81,657,75**
				Per Year		

Step 1 Pick Discount Rate = X %

Discount rate (d) **6%**

Step 2 Select the Time Period = years

Period of Analysis (n) **30 Years**

Step 3 Calculate the NPV = Present Value of equal future savings - First Cost

Simple Present Value PV = A * (((1+d)^n -1)/d*(1+d)^n)

4. CONCLUSIONS

Understanding performance benefits, setting design targets, and identifying critical tasks are new steps in the development process. This presents challenges to a major institution like the City of Seattle that is adopting a sustainable building policy. As evidenced by the first round of this new approach, there are numerous points in the development process that can be accessed for information on benefits and cost, and that also present leverage points for action. These actions should be aimed at increasing the strength and diversity of the building portfolio, and the sustainable building features that they have incorporated. The entire capital campaign can be thought of as a discovery process uncovering the benefits of a sustainable approach, and changing the way buildings are procured by the City.

4.1 Critical Variables

The Evaluation Plan has identified that data collection of actual performance savings is dependent on two important variables: the predictions made by capital facilities designers, and the instrumentation that is monitored by the operational managers. These two stakeholders are currently not well connected by the development process. First cost concerns of the capital facilities project manager can easily overshadow the need for instrumentation that is well integrated into the building fabric. Design of building elements needs to accommodate post occupancy evaluation.

Introduction of the Commissioning Agent and/or M&V provider during the capital planning phase can optimize the feedback mechanisms important to bridging the gap between capital

facilities designers, operations managers, and the entire project team. These players should be considered at the earliest possible point in the planning process.

4.2 Next Steps

As the first series of projects is being completed, there are seven areas that need further development to create a fully operational sustainable building evaluation process. These areas are:

1. Inventories of economic, environemental and social benefits produced by the LEED™ feature set.
2. Linkage of the LEED™ feature set to sustainability indicators that the City wishes to move in the positive direction, providing targets for implementation.
3. Standardization of input variables for utility cost data, life cycle periods of performance, and calculation techniques, so that the right targets are selected.
4. Develop a standard commissioning process for specific project scales or types, which may include a commissioning manual, templates, and a consultant roster, etc.
5. A refined measurement and verification menu that allows project managers to instrument their buildings for targeted LEED™ features.
6. A data collection and review process that provides positive feedback to the budgeting process and project managers on future capital projects.
7. Integration of City building equipment asset tracking and procurement functions in coordination with operations and maintenance services such as maintenance management and warranty tracking.

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Green Architecture is Enhanced through Cultural Connections with the Environment

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INTRODUCTION

The use of "green" building technology has developed in response to global warming, and is available to all architects and consultants; yet the fact that it is not widely utilized in North America diminishes the purpose of the technology. Environmental degradation of the earth's natural systems has been affected by anthropogenic activity and fossil fuel dependent technology that includes modern forms of architecture. A question might be asked: why is green technology not widely adopted over standard forms of building practice, considering the dangerous effects of global warming are scientifically documented? Many cultures have addressed environmental and climatic conditions prior to the advent of the Industrial Revolution and Modern Movement that spawned development in the West and later in urban areas of developing countries. The intention of this paper is to discuss the importance of cultural context in the introduction of "green" or appropriate technology, in light of the growing necessity for its introduce into both developed and developing countries.

HISTORICAL DEVELOPMENT

"Green" technology had its beginnings in the 70s in the form of passive solar design as a reaction to the energy crisis and the recognition that pollution was environmentally hazardous and ethically challenging, as suggested by Rachel Carson in her book *The Silent Spring*. Principles of passive solar heating and natural ventilation were introduced as basic design guidelines and became synonymous with distinctly functional design styles of that period, but also represented principles that could be implemented in any building type. However, little development has occurred since that time. Post Modernism became a prevalent aesthetic reaction to the harshness of Modernism, but the use of fossil fuel dependent technology remained as the dominant method of heating and ventilation.

Issues such as acid rain in the late 70s and ozone depletion in the mid 80s were recognized as unacknowledged family members of the energy crisis. The causes of these problems could be directly traced to the burning of fossil fuels and the consequent massive carbon dioxide production. Canada committed to a reduction in greenhouse gas emissions to 6% below 1990 levels by 2010. The present rate of emissions will put Canada at 30% above 1990 levels by 2010. If existing and new building stock contribute to 30-50% of those emissions, then it is the responsibility of the architect, and those with whom they collaborate to work together to make a significant contribution towards Kyoto's critical goal. If there ever was an opportunity for architects to make a significant contribution globally, this is it (Glanville, 2002).

NATURAL SYSTEMS

Notwithstanding the importance of economic needs and constraints, the health of the biosphere is the limiting factor for sustainability. A prerequisite for sustainability is the restoration and maintenance of the functional integrity of the ecosphere so that it can remain resilient to human induced stresses and remain biologically productive (Rees, 1996). The question might be asked: why is green technology not widely adopted over standard forms of building practice, considering the dangerous effects of global warming are scientifically documented? Future environmental impacts related to global warming have been noted by scientists (Glanville, 2001). These changes will have to be implemented on a regional scale rather than applying standard technology across the board. What is required is the recognition that priorities have to be different in each region (Cole, 2000). Not only do we have to acknowledge local regional conditions in addressing environmental solutions, but also those of culture.

CULTURE

Many cultures have addressed environmental and climatic conditions prior to the advent of the Industrial Revolution and Modern Movement that spawned development in the West and later in urban areas of developing countries. During the 1980's, architectural theory was reawakening to the notion that physical space can possess a spiritual connection with nature as part of a "cosmic landscape." Traditional expression of buildings has informed culture, resulting in vernacular expression within climatic regions. In turn, culture including a spiritual understanding of natural forces, form the basis of vernacular, climatically responsive designs. Future design and planning of communities should consider more than environmental problems beyond the physical expression of a single building; it should involve cultural and spiritual issues of the region in which the settlement is located.

For the most part green architectural solutions have been singular statements rather than pervasive cultural expressions. Prior to the industrial age, traditional building design was characterized by "green elements" such as local material, labor, heating and ventilation methods based on regional climatic conditions. Beyond physical expression in modern structures, few spaces contribute to occupants' understanding of the environmental intention of the design and spiritual quality. Therefore, addressing the cultural/spiritual aspect of locale informs of building intention and, by extension, a connection with the environment.

The key characteristics that define primitive vernacular architecture are designed to be low in their consumption of energy. They are different in their physical appearance since their reaction to different environmental conditions predicates their form. Cultures have not tried to differentiate themselves from each other, but have existed in small groups living in isolation for hundreds of thousands of years, and their differences are a result of prevailing conditions. The features of these vernacular structures contribute to the description of low impact structures, societies, and cultures of the early agriculturally based settlers. They include the following prerequisite characteristics that determine styles typical of a particular culture:

1. use of local materials
2. absorption of solar energy to maximize heating
3. design for shading to maximize cooling
4. design to insulate interior heat and prevent heat loss

5. design for air circulation within interior spaces to prevent overheating, or build up of moisture
6. design of form to resist, or be flexible in movement with prevailing climatic conditions
7. design to utilize landscape and environmental features with the intent of reflecting spiritual cosmological references

The architectural elements of sustainable architecture are similar to those of traditional cultures, though the expression of culture is different. Despite advances in technology that allow architects to ignore many or all of these principles largely as a result of fossil fuel dependence, these principal features can be applied to any example of architecture, vernacular or modern to determine its degree of environmental impact. The exclusion of any of these principles results in the use of fossil fuel. These early structures are low impact, low energy consuming, and regionally environmentally responsive examples of architecture. The degree of adherence to these principles can be used to review existing or proposed buildings in current architectural practice to determine their degree of "appropriateness."

IMPLICATIONS OF APPROPRIATE OR GREEN ARCHITECTURE

It is important to note that while contemporary buildings may be analyzed as "green" or "low impact," they may utilize only a few of these features as a gesture of intent to be considered energy saving in a setting where the environmentally responsible practice of architecture is very low. Although there are computer programs that analyze the efficiency of buildings, the analysis is meaningless if the programs can manipulate the degree of appropriateness, given the magnitude of the global warming potential.

To adhere to principles of environmental appropriateness similar to those expressed in vernacular architecture would obviously result in a greater reduction of energy use and therefore reduced greenhouse gas emissions. Design restrictions and building code standards that impose restrictions can be seen as a violation of freedom of expression, regardless of future implications. The question then becomes one of adaptation or avoidance of climate change and brings into question another dimension of the problem of global climate change; that of individual and collective responsibility in addressing appropriate or green architecture.

ENVIRONMENTAL SEPARATION

To explore the roots of separation of mans' understanding of the environment the writer has attempted to define the principles of vernacular architecture, and give examples of the resultant forms. The characteristics of vernacular can be extracted and defined in terms that can be applied today, or as described as appropriate architecture in this paper, without having to reflect past styles. The traditional principles of vernacular architecture that were developed without the use of fossil fuel were repeated and refined prior to the last two hundred years in contrast fossil fuel dependent freedom of expression in lieu of traditional design principles.

The principles of vernacular architecture also define appropriate architecture, and any deviation from those principles defines less appropriate green measures. When one reviews types of vernacular architecture as they have been refined through history, many of the features remain the same, with the exception of aesthetic details that typify a period. Advances in technology have always given designers and builders the opportunity to augment existing technology. In broad strokes, one has only to review the technical advances from Greek and Roman architecture to

Medieval to Gothic to Neo Classical and finally to Modern architecture and the International Style.

The writer argues that the proportionate advances in technology are in opposition to the connection with nature. The changes in architecture from traditional vernacular to modern symbolize the separation of mans' awareness of his place in the environment. Since we live in an age where this lack of environmental connection is expressed, this separation has contributed to scientifically proven environmental damage. As a result, the scientific community has warned us of our anthropogenic activity and has physical proof of the resultant changes (Glanville 2000).

So we find that we have come (almost) full circle. We now have a need for a new kind of architecture, one that is at least green in a technical sense, and at best appropriate in a cultural sense. In order for a building to be designed appropriately and with the least environmentally devastating effect, the principles defined must be employed, those that evoke traditional architectural principles that have proved effective through history. The modern architectural model cannot hope to confront environmental crisis as it has a limited vocabulary with which to speak to environmental concerns. Modern architectural practice and education was not structured on understanding the environment, rather defying it. One has only to look to any major urban setting and find that, as defined by the International Style, buildings share the same characteristics, but are situated in different climates. The different is that those located in cold climates require fossil fuel fired heating, while those built in hot climates frequently require fossil fueled air conditioning. Since traditional vernacular expression has been subordinated both in practice and in education, the vocabulary of environmental response has been dominated by a vocabulary of self-expression.

MEANING

Human cultures personify human life and a culture itself is reinforced by its architecture. The distinctive cultures that were shaped by traditional forms of architecture still exist, though in dwindling numbers. The social structure it supports is also weakened. In this case with limited social reinforcement of vernacular architecture, the connection with nature is further weakened.

Different cultures respond to the environment differently. This is in part a result of local climatic conditions, but also as a result of the cultures that have developed around the understanding of the environment that shaped culture as influenced by religion, language, and politics. The connections people have with their cultures have been expressed in the vernacular forms of architecture that are characteristic of their environment. The architecture is representative of the fundamental understanding cultures have with their sense of identity. As a result, it might be suggested that cultures other than those of western Europe and North America may not adapt sustainable architectural principles as easily. Western implementation of these features, though not often chosen, does not result in significant change to the appearance of western buildings. In cultures where western technology has been introduced and is not the first language in buildings, the choice to adopt standard technology has either been made, and therefore is as difficult to change as in the West, or does not suit the vernacular language and local culture, thereby limiting its implementation. For example, local indigenous Canadian traditions suggest that a sacred approach to land and its inhabitants be taken in opposition to prevalent forms of western development. Some Asian traditions have adopted a philosophical, if not fateful attitude to development, while others grasp at technical development at any cost.

Other cultures include more traditional forms of cultural expression influenced by traditional roots. These early influences affected culture and they honored relationships to nature. The first concern of all human culture is that their story be understood and they are defined as different to show the vitality of each. This notion is expressed in language, architecture and religion, is irreducibly real, and deepens our sense of who we are.

Traditionally, living was a religious act where the world was experienced as sacred. Consciousness of meaning in culture reflects our understanding of existence. When this understanding is translated into form, whether it is architecture or language, existence is replicated. Built form is a replication of our understanding of existence. In traditional societies, to be truly human is to be initiated into the local story, or history of understanding of existence. This existence was interpreted and understood in architecture. Architecture was about the transformation of understanding of existence into form. Since human beings have the imagination to live beyond reality, we have to remind ourselves of our connections to the world. The connections are realized through creation, life and death as an existential energy of our existence. Estrangement, or absence of being, occurs when we do not remember our connection with the existential. Estrangement can become systemic.

Religion typically represents resurrection from estrangement. Prayer is an art that restores the capacity to be in the "presence" through recognition of the seasons of life. It is not surprising that early sacred architecture attempts to restore the connection to the "presence" and physically represent the axis mundi through interpretation of the cosmos, or in an image of god in man, sacred space. It has been suggested that the ecological movement fills the void of disconnection of being in the world (Goa, 2002). Therefore the fundamental problem is how we perceive and live in the world and that modernism leaves room for that reconnection with nature. The idea is that there is a power that operates beyond our understanding and we should honor it.

Spaces and elements affect occupant connection with the environment and therefore inform an inherent spiritual connection between man and nature through buildings. All real knowledge does not come only through technical knowledge. It is suggested that building expression indicates a direct connection between cultural expression and use, and awareness of the natural environment, and demonstrates that truly green building requires a spiritual/cultural connection as an inherent component.

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The potential for prefabrication in UK Housing to improve sustainability

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1. INTRODUCTION

Off-site, factory production of dwellings has the potential to lead to significant improvements in both the quality and speed of construction compared to traditional site-based construction. The technical benefits include increased speed of production, reduced levels of defects and waste, greater efficiency in the production process, and improved environmental performance. These are all generated as a direct result of moving more of the construction process from the building site, where efficiency is poor and management difficult, into the relative safety of factory conditions, where efficiency and control can be better managed. This can also lead to social benefits including improvements in health and safety, more stable employment and investment into machinery and development of skills. Greater stablility in the manufacturing process also generates potential economic benefits.

All of these contribute to environmental, economic and social benefits of sustainability. This paper will review the sustainability benefits of prefabrication, and look at the various alternative ways that prefabricated building systems are beginning to have an impact on the way residential buildings are constructed in the UK.

2. UK CONSTRUCTION

In the UK, government predictions suggest that 3.8 million additional new dwellings will be required over the next 25 years. Current replacement rates are minimal, with most new housing adding to the stock rather than replacing old, outdated housing. Within the social housing sector it is estimated that from 2000 to 2016 one million new dwellings will be required. These will be mainly in the form of high-density terraced houses and purpose built flats. This presents a significant challenge to the UK construction supply chain with its diminishing labour force and increased business performance demands. Furthermore, client requirements for higher building standards and the industry's increasing regulatory improvements, particularly in thermal and acoustic performance, and health and safety issues are pushing the industry to reconsider on-site methods of construction and to investigate other ways of building homes.

However, until recently prefabrication in housing in the UK has been associated with a reduction in flexibility and choice for the designer, client and end user, and with higher costs. Market resistance has prevented significant uptake of such technology in the UK despite examples here and from abroad illustrating its technical feasibility.

To address these issues, government backed reports such as "Constructing the Team" (Latham) and "Rethinking Construction" (Egan) have clearly identified that the construction

industry must change its way of working if it is to prosper and serve the needs of society. Construction must address market demands of improved efficiency, better quality, faster construction and better cost control. Other pressures to change the way we build have come from increased concerns about the impact of the construction process on the environment and local communities and the chronic skills shortages of site skilled labour. This has led clients to take increasing account of the sustainability impacts of how we build, as well as how we operate and maintain our buildings. It has led to a greater interest in off-site manufacturing technologies and house builders are currently investigating a variety of innovative ways of building dwellings. Recent reports (CRISP) have identified considerable areas of overlap between the agenda of improved industry efficiency through prefabrication and partnering, and the sustainability agenda.

3. OFF-SITE MANUFACTURING SYSTEMS

In the UK there are three principal approaches to off-site production of buildings using lightweight construction currently being used. These are discussed below:

3.1 Volumetric systems

Three dimensional units are manufactured in the factory with a high degree of services, internal finishes and fit-out installed in controlled, factory conditions prior to transportation to site.

This has many benefits including improved quality, reduced defects and snagging on-site, increased speed of construction on site, better working conditions, increased predictability and efficiency in the production process. This approach is particularly suited to highly serviced areas such as kitchens and bathrooms, which have a high added value, and cause disruption and delays on site, but may be less appropriate for other rooms which have less internal fit-out. For this reason some recent high profile projects have used volumetric bathroom pods in conventional residential buildings.

Volumetric systems have the disadvantage that each unit has to be transported separately, and the maximum size of the unit is determined by the practical problems associated with transportation by road. The factories operate most efficiently when a large number of similar units are made to the same dimensions. Both of these factors work to reduce flexibility in layout and design. For these reasons most volumetric construction in the UK to date has been in the hotel, hospital and fast food chain sectors, where repetition of units is possible. In addition, because the units have to be self supporting and are craned into place on site, the strength and rigidity must be sufficient to allow this process to occur without damaging the unit. The strength requirements for lifting operations may exceed those for in-use service, thus the structure may be over-designed for its end-use, leading to wastage of materials.

3.2 Panellised systems

Flat panel units are produced in a factory, and fixed together on site to produce the three dimensional structure. Services, windows and doors, internal wall finishes, and external claddings can potentially be installed in the factory but in most current systems in the UK the services installation, external cladding and internal finishing occurs on site.

Panellised systems are more flexible and can more easily accommodate variations in unit plan and detail design than volumetric systems. Spaces such as bedrooms and living spaces lend themselves to panel construction systems, providing greater choice to the client and designer,

with few restrictions on room size and layout. Furthermore, panellised systems have the advantage that, because they can be stacked flat, more of the structure can be transported in one journey. However, the levels of finish and services which it is practical to install into panels prior to shipping to site are reduced compared to volumetric.This leads to more work on site and requires further deliveries of other materials, components and labour to site. This may be appropriate for plain walling but would be a disadvantage for highly serviced areas such as kitchens and bathrooms. Also, there is a greater likelihood of damage to the finishes applied to the panel during transportation or on site.

3.3 Hybrid (semi-volumetric) systems

A third option which maximises the benefits of prefabrication is to combine the benefits of volumetric and panel construction by using volumetric units for the highly serviced areas such as kitchens and bathrooms and constructing the remainder of the dwelling using panels. This offers the opportunity of bringing together the benefits of each system, and address the issues of providing flexibility and consumer choice.

Such an approach may combine the benefits of economies of scale and the economies of scope, utilising mass production, factory production and standardisation to provide flexibility of options offering customisation. A kit of parts can be used to provide flexibility yet maintain the benefits of standardisation.

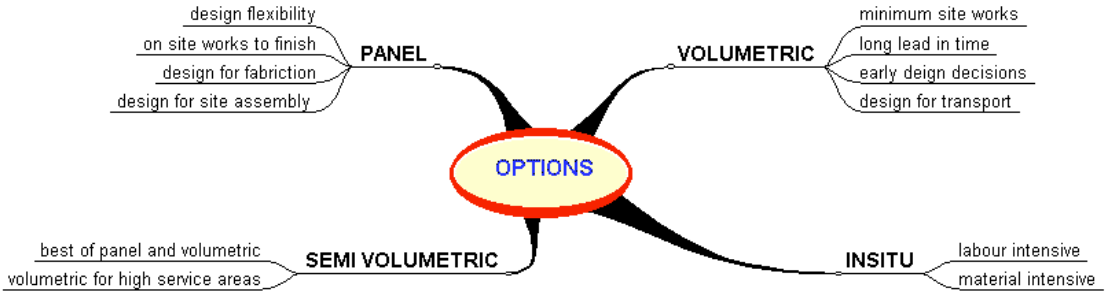

Figure 1 Features of prefabricated housing

4. SUSTAINABILITY BENEFITS

Prefabrication can address a wide variety of sustainability issues. Some of these are discussed below:

4.1 Reduced local impacts

One of the key features of prefabrication is that much of the process is removed from the site to controlled factory conditions. This reduces the amount of time spent on site, which leads to reduced impacts on the locality. Experience in the UK shows that prefabricated hotel buildings can be constructed on site in less than half the time of a traditionally built hotel of a similar size. This means that the locality around the site is disrupted for a shorter period reducing noise, pollution emissions and local traffic disruption. Furthermore, the lightweight nature of the buildings can often result in smaller foundations and therefore less groundworks, also reducing local disruption as well as reducing the volume of materials used in the groundworks.

From a financial point of view the shorter construction period allows a quicker return on investment by the client, and reduced overhead costs.

4.2 Reduced levels of defects

Achieving quality construction is often very problematic in difficult, exposed site conditions. Factory based activities allow better quality management, with testing and checking procedures more easily implemented. For example, volumetric units can have electrical and water installations fully tested prior to leaving the factory. General experience in the UK suggests that far less call backs are necessary to make good defects after completion for buildings using a lot of prefabrication. This is a significant cost and effcciciency benefit to the builder and leads to satisfied customers. It also improves efficiency and reduces wastage of resourcs.

4.3 Less waste in manufacture

Waste from construction is one of the principle waste streams in the UK leading to at least 70 million tonnes of waste per annum. Manufacture in a factory allows far better management of the waste stream with more efficient use of materials and ordering of exact amounts of material, more careful storage, and the possibility of design to suite standard sizes. In addition any waste that occurs can be more easily collected and reused or recycled. Many manufacturers of components have recycling facilities installed, as this reduces the costs of disposal of waste. There is further potential for reducing waste when using prefabrication if the designer is prepared to co-ordinate sizes so that materials such as timber and gypsum sheets are used in their standard sizes without generating many offcuts.

Assembly of prefabricated components on site should generate little waste as the components come to site pre-engineered to assemble together.

4.4 Health and safety benefits

Construction work on site can be a dangerous activity and leads to significant numbers of casualties and fatalities. More demanding health and safety requirements are pushing many builders to consider off-site manufacturing techniques. This allows much of the process to be carried out in more controlled and comfortable factory conditions where safety requirements can be more easily met and policed, and healthy and comfortable working conditions are more readily maintained. The use of scaffolding is a particular concern, and some schemes in the UK have tried to eliminate the need for scaffolding completely by integrating claddings in the factory. Conversely the use of heavy lifting equipment too locate the prefabricated components on site requires careful management.

4.5 Improved environmental performance of the final product

Thermal and acoustic performance is very dependent on the quality of workmanship and supervision. The correct installation of the elements of the fabric, in particular insulation materials and air barriers are important to the performance of the building in use. Factory manufacture allows operatives to be better trained and supervised in these tasks, and allows regular checking and testing of performance. Problems such as omitted insulation and badly fitted air barriers are less likely to occur. Reports from North America suggest that direct comparisons show higher thermal performance standards for homes that use off-site manufacturing techniques.

4.6 Social benefits from improved working conditions

Employment at a factory manufacturing prefabricated building component is generally more stable and long term than site based employment, which is intrinsically transient. As a result, factory based employers are generally more willing to invest in training for their workforce. Furthermore, to function efficiently prefabrication requires high levels of skill and flexibility in the workforce. This necesitates greater training by employers.

Building sites are temporary employment locations, so they generally offer little long term amenities for the local community. Manufacturers in factories are often closely linked with the local community, with much of the workforce coming from the locality. They provide a long term economic and often social service for the community. Many manufacturers of prefabricated modular or panel units in the UK are well established in particular locations and have developed a highly trained local workforce, and strong links with the local community.

4.7 Greater efficiency in the use of resources, both materials and labour

Building sites are notorious in the poor efficiency in the use of labour and materials. Studies in the UK have shown that site based activity has a considerably lower efficiency in the use of labour compared to factory based activities. In some cases the useful activity on site can be below 50% of full poitential. Furthermore, it is estimated the between 13% and 18% of materials delivered to UK construction sites is wasted and never used properly. Manufacture in the factory allows higher levels of efficiency to be achieved.

In addition, volumetric construction using prefabricated pods or modules allows building to be potentially dimantled and the modules reused at a different location. Modular hotels in the UK have been dismantled and removed to a different location when found to be uneconomic at their original site. Similarly, many volumetric buildings are used as temporary buildings and removed for reuse when no longer necessary. Thus, the technology for reuse is established. Many of the materials used in this type of construction such as the steel framing can also be extracted for recycling at the end of the life of the module. This is made easier by the lightweight, dry construction methods that are generally used. This is likely to become more significant in the future when EEC legislation about producer responsibility encompasses the construction industry.

4.8 Transport

Transport is a complex issue, and monitoring of transport patterns relating to construction sites is difficult. In general, prefabrication leads to a reduction in the numbers of deliveries to site compared to traditional construction methods. Some monitoring of a site in London suggested that deliveries to site were reduced by up to 90% for a volumetric building compared to a similar building nearby. However, these are generally large vehicle deliveries often coming considerable distances from the factory. In addition, the shorter period on site and the nature of the work means that less labour is required on site and for a shorter period. Thus, in general it is likely that a well managed site using prefabricated components can significantly reduce the impact of transport.

Conversely the additional transport movements related to the factory should be considered. However, the workforce in a factory is more likely to be local than at a building site, and thus will travel shorter distances, and is more likely to use public transport, where possible.

Secondly, material deliveries to a factory can be planned so that full loads are always delivered, and local suppliers can be used.

5. CONCLUSIONS

The objectives of sustainability and the 'Rethinking Construction' agenda of improving efficiency in construction overlap in several areas, notably waste minimisation, process integration, a commitment to people and a quality driven agenda. Prefabrication offers an opportunity to address both these agendas, and improve both efficiency and sustainability. However, the industry has much to learn to fulfill the potential of this technology. The following points should be considered:

1. There is an increasing interest in prefabrication in the UK house building industry. This is partly due to the effect of the report of the Construction task Force "Rethinking Construction" published in 1998. Furthermore, house builders are beginning to realise that there is a need to improve standards and that new regulatory requirements such as the changes to Part L of the Building Regulations dealing with energy efficiency will be more easy to satisfied by increasing the amount of off-site manufacture.
2. There is a well established sector of the construction industry manufacturing volumetric units for hotel construction, key worker accommodation, the education sector and budget restaurants. The economics of this type of construction relies on repeatable units so that large production runs can be set up. A figure of 40 repeatable units (of similar size and layout) is sometimes quoted as a minimum number required for such systems to be cost competitive. Another sector of the industry provides a wide range of panels mainly for housing units.
3. The volumetric manufacturers have developed technical systems and construction processes to maximise the benefits of this type of construction. The management of the construction process has been identified as a particularly important area, and the interaction of the prefabricated components with site processes such as foundations, service connections and cladding are critical.
4. Health and safety issues are driving many changes in approach. The elimination of scaffolding is seen as a desirable objective.
5. Many of the companies developing off-site manufactured systems are investigating options for alternative claddings to traditional brickwork. The perceived market preference for brickwork is seen by many as a potential obstacle for wider adoption of prefabricated systems. Alternative cladding systems are being developed with improved detailing. Many UK schemes using prefabrication also use alternative cladding systems such as cedar boarding, polymer based renders or rainscreen cladding.
6. When considering the technical issues of off-site manufacture it is essential to also considered the process of manufacture and assembly. Technical decisions can lead to process problems, and so both must be considered together.

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Introducing practically the environmental concern when prescribing construction products

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1. INTRODUCTION

Spurred on by all the protagonists of building sector, it becomes possible to take into account environmental characteristic of building products using a new methodology and new tools. The XP P01-010 experimental French standard on "Information concerning the environmental characteristics of construction products" and the future INIES BASE database result from national consultation and consensus.

The environmental impacts are actually a major concern in the minds and habits of the French construction sector professionals, as far as more and more briefs do specify environmental performance. It occurs mainly for public works like high schools (Lycée Léonard de Vinci in Calais [1]), hospitals,.. The requirements are normally expressed at the building scale, but even if a building is recognized as not only the addition of its components, they are mostly translated in terms of environmental characteristics for the construction products.

Consequently, the architects, designers, environment consultants, building owners (more generally the specifyers) need understandable and simple data, so that they could add environmental criteria to the set of information usually attached to the construction products without strong changes in their daily practice.

It is included in the missions of CSTB to provide the specifyers with practical and usable information, while guarantying objectivity, relevance and data quality. In the case of environmental data, it appeared as a huge task, to produce the simplest possible communication figure out of the detailed environmental assessment results. This paper describes rapidly the steps already made by CSTB and his partners, presenting more in details the standardisation work undertaken by AFNOR, and finally introducing briefly the new data base INIES-Base designed for help in decision making.

2. FROM LCA TO ENVIRONMENTAL DECLARATION

With the support of ADEME, CSTB first investigated early in 1993 the adaptability of the LCA methodology to the construction products, with their particularities. The conclusion of a

deep research work achieved in 1996 [2] resulted in the recognition that LCA is the only way to get relevant data, but identified also the main particularities of the building products to be considered for specific recommendations when conducting a LCA in the construction sector. We pointed out particularly the data uncertainty and variability [3], the relevant system boundary identification [4]. We shared our approach at the European level through a Brite Euram project, worked out in partnership with several European Building Research Institutes [5], and finally we developed a specific tool: Equity 2.0 [6], experimented through specific studies [7], and then used for direct consultancy in LCA processing for clients from the building product industry (clay tiles, AAC blocks, ...).

The same methodology, strongly improved by taking into account the conclusions of the SETAC Group on LCA in Building [8], is now the basis of LCA approaches in different European projects, dealing with innovative materials and products for application in partition boards, insulation, windows, external renderings...

Nevertheless, early in 1998, it has been clearly stated that life cycle inventory data would never been used easily by specifyiers without any simplification or at least organisation. While in several European countries the environmental declaration concept was growing, we developed in France with several partners a new tool targeted towards specifyiers for decision making. This set of 4 grids (one for each main life cycle stage), already called INIES, was only a classification format. environmental and sanitary information are gathered and organised into tables where the effects of the inventoried flows on major environmental themes are analysed in terms of risk management [9]. Again with the help of ADEME, it has been documented for almost twenty product families, and already presented in that form in different places [10], [11].

But we faced then the main difficulty, related to data quality, and resulting from the lack of consensus on the communication rules and format for the data. For that reason, it was decided to postpone the further development of INIES until the establishment of rules for the input data provision. It Came from the standardisation work described below.

3. THE EXPERIMENTAL FRENCH STANDARD XP P01-010

After an intense collaborative working period with all the building sector protagonists, the French national committee AFNOR P01E, published in April 2001 the first part of the XP P01-010 experimental standard, and in March 2002 the second part of this standard [12].

Part one draws up the list of information to be communicated for a building product. This information is based on a life cycle inventory in accordance with the life cycle assessment principals. The part two enables to assess the building products' contribution to the total building environmental and sanitary impacts. Part two explains how to use data from part one to complete the impact assessment. This part is in accordance with the ISO 14042 standard.

Part one describes a general declaration model (formatted data sheets) for environmental and sanitary characteristics of building products and the methodology to collect, aggregate and assess these characteristics.

The general methodology is based on the life cycle assessment methodology. So the ISO 14040 and ISO 14041 standards [13] are the two major references for the experimental XP

P01-010-1 text. The standard proposes a life cycle inventory formatted for building products assessment.

The life cycle of a building product is divided into 5 main stages:
- production (including raw materials extraction and manufacturing),
- transport (transport from manufacture to the construction site)
- setting up (building construction to acceptance)
- service life
- end of life (building demolition or deconstruction and waste transport to disposal or reuse site).

The inventory is given for a functional unit (the standard proposes rules to define it, some examples are given). The LCI results are given for each main stage of the life cycle (per one year period), for the total per one year-period and for the total life cycle (the total life cycle data is the "per one year period data" multiplied per the typical lifetime of the product). To establish the LCI a general mass cut of rule (95%) is used. Some restrictions of this general rule are proposed for dangerous substances.

The LCI is divided into categories of flows:
- consumption of natural energy resources and energy indicators,
- consumption of natural non energy resources,
- water consumption,
- consumption of recovered energy and materials,
- air emissions (emissions during setting up and service life are separated),
- water emissions (emissions during setting up and service life are separated),
- soil emissions (emissions during setting up and service life are separated),
- recovered waste,
- eliminated waste.

Part two of XP P01-010 standard gives some guidelines for the application of environmental and sanitary characteristic to given construction works. Part two indicates how to use data from part one to assess the products'contribution to the environmental impacts of a given building and health risks and comfort into this given building.

Based on the general ISO 14042 principles, for environmental characteristics, part 2 proposes some environmental impacts categories for building products. Impact categories are divided into:
- relevant for all products,
- relevant only for some products.

For sanitary and comfort characteristics of building products, a list of relevant data needed is given. This list was established in accordance with the requirements of the construction product European directive 89/106/CE.

Table 1 : environmental impacts categories used in the XP P01-010-2

Impact category	relevant for all products	relevant only for some products	impact indicator/unit
Consumption of energy resources	X		MJ/FU
Consumption of non-energy resources	X		kg/FU
Water consumption	X		L/FU
Solid waste	X		kg/FU (total recovered waste, dangerous, non dangerous, inert, and radioactive eliminated waste)
Climate change	X		Global warming potential (GWP) in kg eq.CO_2/FU
Atmospheric acidification	X		Acidification Potential (AP) in kg eq. SO_2/FU
Air pollution	X		Critical volume in m^3/FU
Water pollution	X		Critical volume in m^3/FU
Soil pollution		X	qualitative
Destruction of the stratospheric ozone layer		X	Ozone destruction potential (ODP) in kg eq. CFC R11 /FU
Formation of photochemical ozone		X	Photochemical ozone creation potential (POCP) in kg eq. ethylene /FU
Affecting of biodiversity		X	qualitative

4. FROM STANDARD TO PUBLIC INFORMATION

Final users of environmental and sanitary characteristics want to get reliable and clear information. In accordance with international 14020 standard series, the experimental XP P01-010 standard reminds that misleading affirmations are to be prohibited.

Final users of environmental and sanitary data need to analyse and to study these characteristics in relation with the intrinsic quality of considered building and with the stakeholders' targets. Following the same objective that the former INIES grids, but now with clearly assessed input data, the INIES BASE project, based on the XP P01-010 methodology is designed for users that want to get different information levels:

- Information search relative to environmental and sanitary characteristics: does this product have a significant impact on my building project?
- Access to more detailed information with an adaptable filter designed for a product or building functionality (insulation, conformity to regulations, contribution to local, regional and global environmental equilibrium…)

A short description of the project follows, as the work is still running at the moment.

5. INIES BASE DATABASE

The authorities support CSTB to develop INIES BASE, with a strong requirement for a consensus work, through the advice of a working group (see below). This database will enable to organise and to display synthetically all the environmental and sanitary characteristics of a building product to promote their use.

An INIES sheet can be generic (for a products' family) or specific (for a referenced product). Each sheet contains:

- a descriptive sheet of the product with, especially, the functional unit used and some technical characteristics,
- several grids (one for each major step of the product life cycle). Each grid is a table with flows in lines (energy, raw materials, emissions) and environmental topics in columns (resources' preservation, natural mediums preservation, waste, health…). An information on the potential contribution of the flow to the environmental topic is given in each square.

INIES BASE will probably also present the results of environmental and sanitary impact assessment of building products in accordance with the XP P01-010-2.

The computing tool is under construction. A working group chaired by ADEME with representatives of all building sector protagonists assures the coherence of INIES BASE with national committee AFNOR P01E works. This working group is completing potential final users' interviews to test, review and improve the tool. INIES BASE should be available on Internet at the end of summer 2002 with about forty products.

6. PROSPECTS AND CONCLUSIONS

These new tools will gradually enable to introduce environmental and sanitary criteria when prescribing construction products.

XP P01-010 as an experimental standard will be revised in 2003. During the experimental period, it is expected that a great number of declaration will be issued.

On the international scene, the French standard is a contribution to the work item on environmental declarations within ISO/TC59/SC3/WG12 “Sustainable Building”.

The main weakness of XP P01-010 is the question of data quality (already addressed in the general LCA methodology applied to building products [14]) and data review. XP P01-010 declaration is a type III environmental labelling, but with a self declaration effective status. No peer review is imposed in the French standard, so the question of data quality will probably appear in the ISO harmonisation works, provided that the question could be solved in the ISO TC207 context.

As far as INIES-Base is concerned, a minimum of one hundred of generic products covering all main families of building products is a reasonable objective for becoming an effective prescribing tool. After this first step in the introduction of environmental concerns in prescribing activities, manufacturers will probably wants to communicate about their specific products, and it will be the second filling step of INIES-Base. Finally INIES as a communication format is actually being used for introduction of environmental criteria in the French technical evaluation procedure, called Avis Technique [15].

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New system for optimised maintenance planning for Oslo municipality's dwellings

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1. INTRODUCTION

Oslo municipality Boligbedriften (BOB), together with Interconsult and NBI, started January 2001 a two-year project with the purpose of finalising the development of the existing prototype for Service Life prediction into a fully generic product to be used in most facility management tools. The project includes activities as:

- Integrating the Service Life prediction tool with existing facilities management tool (TiPS)
- Educate and train the staff members in BOB in day-by-day use of the system
- Increase the use of standardised methods for condition assessment and maintenance planning.
- Accomplish Service Life analysis for BOB's property, based on a combination of actual data for different houses and available statistic information.

Another important objective for Boligbedriften was to get strategic information for political decisions, and to document the financial need for repairing the building stock and maintaining a certain quality.

The project is a further development of systematic and it-system developed in 2 previous EU-projects; Wood-Assess (ENV4-CT95-0110) and MMWood (ENV4-CT98-0796).

The paper will describe the overall documentation system and the reorganizing process.

2. OSLO MUNICIPALITY BOLIGBEDRIFTEN (BOB)

Oslo municipality Boligbedriften administers 8800 rental objects, mainly dwellings, and is obliged to do this on a strictly business basis. Therefore the organisation decided to implement a new system for documentation of the buildings and all its related activities, and in connection with this it also became necessary to reorganize and change the routines in the organisation.

New demands for documentation of quality and environmental impact, together with decisions that public services are obliged to take life cycle costing and environmental impacts into consideration when planning purchasing and work, made it necessary to have a system that was able to handle this information and documentation.

Important issues and objectives for BOB was:

- Get a survey and better documentation of the building stock
- Provide a better view of condition, costs and need for maintenance for all main parts of the building, including description and documentation of effects and costs for BOB by postponing maintenance and repairs.
- Provide a plan for maintenance and repairs on both short and long term.
- Carry out a total Service Life analysis for the building stock
- Do an optimised valuation and rent calculation for the flats and building stock
- Description of needed internal and external competence both for carrying out the project and for future work

The standard of the buildings has to be improved, but this will take years and a lot of resources. In the mean time the organisation needs a system that relieves the technical department from work and procedures others may do, and which ease the information and communication in the organisation.

3. GENERAL NEEDS, REQUESTS AND DEMANDS CONCERNING NEW IT-SYSTEM - AIM WITH AN INTEGRATED IT-SYSTEM

With integrated databases the organisation will ensure that all departments or functions are using the same information, and that the information only has to be updated once into one system. The different departments in BOB needs to achieve a common understanding of need for precision of information, for instance correct addresses and names of tenants, and the staff has to be loyal to this system. An aim with the it-system is to replace today's system with notes and phones.

The main it-system shall handle basic building or property information, as names and addresses of buildings, number of flats, size, standard etc, mainly imported from public registers. Drawings and photos are connected to the buildings/properties. All buildings are shown on map by a GIS-system.

Earlier BOB had the problem that building information used for deciding rent and the one used in the invoice system differed, and they often both differed from official information. The tenant register now will use the common building information.

The organisation is aware of the importance of choosing the correct data to put into the system, both to avoid unnecessary time used to describe data that will not be used and to ensure that other departments find the information they are seeking. This revels a need for instructions and rules for how to register information and the responsibility for registration. All information should be registered in a clear and, if possible, unique way.

By use of interviews with several persons in the organisation, the following decisions where done concerning necessary information:

- All information should only be registered once, both for time saving and to ensure data consistence.
- Need for criteria for updating of information

- The system must be flexible and user friendly for registration, reading, analysis and reports.
- The information in the system must have a sufficient quality for budgeting
- The registration system should be based on Norwegian or international standards when available.
- Drawings of buildings should be taken from the municipalities' records or archives.

The day-by-day management are done by IBMs TiPS^{FM} (Total Information & Planning System for Facilities Management), which also are selected to handle the main building documentation. TiPS is handling and follows up work-orders.

A new it-system, Slipis (Service Life Inspection and Planning of Infrastructures System), is developed to handle preparation of inspection plans and programs for the building stock, follow up the plans and programs with work orders for inspections. Slipis will also be the main system for condition assessments.

4. USER NEEDS FOR ORGANISATION AND PERSONNEL

Mapping of user needs showed clearly that the persons in different departments sees different effective outputs and have different needs they hope the new system solve. For the organisation it was important that they had a common understanding of the effective output for the organisation as a whole.

Implementing a new total it-system in the organisation involves a reorganisation of the routines in the organisation. For information registrations this means that some user groups may have to register more information than they need themselves to ensure that this information is available for other user groups.

Due to this there was a need of draw up a common code of practice; first of all a Quality Assurance System. The superior administrative handbook must be prepared in such a way that all premises and the governing documentation give precise guidelines for preparing operative manuals for the different departments. New procedures have to be described and documented, and development of the it-system has to take this into consideration. The governing system also has to give description of what goals BOB has and what is minimum acceptance in accordance to quality and standards; i.e technical, environmental, functional specifications.

The new integrated it-system also gives a need for all personnel to have appropriate it-equipment, and this release a need for investment in new equipment and internal training.

Already in the project's planning phase BOB uncovered a large lack of necessary capacity and competence in many levels of the organisation for carrying out the project. Temporary lack of capacity for condition assessment and building documentation was bought from NBI and Interconsult as a part of the project. Additionally several work shops and training sessions where held to increase the competence in BOB.

5. SLIPIS - SERVICE LIFE INSPECTION AND PLANNING OF INFRASTRUCTURES SYSTEM

Slipis will be the main system for condition assessment and maintenance planning. It consists of several modules, as:

- Assets, which is a module for handling building information, including documentation of building parts and material.
- Condition Assessment, which is a module for planning and programming the inspections as well as for carrying out the condition assessment itself.
- Service Life Prediction module including an environmental risk factor assessment module, used for service life prediction and mainetenance planning.
- A maintenance planning module for optimised mainetenance planning, including cost and decision module (not yet tested)
- Report generator and fully developed report templates for the most common reports from the system
- Photo server

Slipis is a GIS-based system, and all buildings are related to a building point. The maps are also used for showing the geographical information concerning environmental exposure and environmental risk factors.

Drawing can be linked to all buildings, and building parts as well as condition/damages may be marked on drawings by separate layers.

Photos may be imported directly to the photo server from digital cameras or from a file server. Photos can be linked to all objects in the system; as buildings, building parts, inspection and condition. The systems allow directly editing of the photos.

All digital documents (including drawings, word-doc, photos etc.) may be linked to any object in the system. This function gives easy access to available and important document, both for reading and editing.

Slipis contains systems for inspection, with predefined types of inspection with a number of forms for condition assessment. A lot off effort is done predefining the types of inspections, containing level of inspection, building parts to be inspected and what information to collect during the inspection. The system database contains predefined systematic lists for building parts and materials, list of symptoms that is filtered depending on chosen building part and material, possible causes for damages, possible agents for deterioration, condition degrees, and consequence degrees with regards to economy, health, safety, environment and aesthetics. There is also predefined list for other properties to as much as possible ensure systematic registration and prevent the use of free text.

Registration of condition degree and consequence degrees is the must important factor for use in further planning and economical optimisation. This is the important factor used for prioritising in the maintenance planning and decision module.

The system will allow inspections and condition registrations online by use of PDA, and the databases will be updated at once. An off-line PDA registration system will also be available.

The systematic way of to register building parts, materials, year for last maintenance and actions, condition degree and extent of symptoms, enables BOB to make statistics for service life, and to predict time for next inspection and maintenance actions.

The service life prediction module includes prediction of service life by use of dose-response or damage functions, with input describing the environmental exposure. Service life

prediction is also made by use of the Factor method defined in ISO 15686-2 “Buildings and constructed assets. Service life planning. Part 2: Service life prediction procedures”. The factor method takes, when finding estimated service life into account the reference service life, the external/internal exposure, quality of material and work, and maintenance level.

6. COLLECTING BUILDING INFORMATION

The main activity for BOB during the project period is to collect building information, both from own registers and by inspection. The organisation was already in short of work capacity, and new tasks demanded a strict decisions concerning work priority.

There have been held several workshops for the people involved to prepare them for the huge work with building inspection, with registration of building and condition information. People from Norwegian Building research Institute (NBI) and Interconsult have been assisting BOB at the inspections.

Before the inspections took place, it was developed a system with forms describing what information to collect and how to register this data. The work was done in cooperation between the partners in the project.

The first year 20-25 buildings were inspected, and the plan for year 2 is 50 buildings. Total 50% of the blocks of flats are to be inspected, while the houses will be inspected at a later stage or when changing tenants.

Also the caretakers for the buildings should use the management system, and since many of them was lacking he necessary ICT-competence and experience, on-the-job training was planned. ICT-competence will be a new demand when employing new people.

7. EXPERIENCES FROM THE PROJECT

To succeed with such a project, the management and head of organisation must be willing to put in the necessary effort, and must be able to motivate the staff members into participation. In an organisation with a shortage on people and a large labour turnover, this was the main challenge.

Both the persons responsible for planning and organising the condition assessment, and the staff that carried out the inspection had difficulties in setting aside time and resources for the work. Even though everybody individually was positive to the projects, the organisation as a whole had problems with the accomplishment of a project this size. Because of this, BOB had to buy more external services than planned, mainly for the inspections and data collections. This again led to less on the job training for the BOB staff.

Development of new procedures made several changes in peoples daily work, and it was an important issue that the procedures was developed in close cooperation with they who where influenced by the changes. The procedures had to be accepted in the organisation before they where introduced by the it-system. This experience gave the persons involved an “ownership” to the project and the it-system that was positive for carrying out the project.

8. CONCLUSION

Integrating a total new it-system with completed with new procedures and new and more systematic ways of working demands a lot of an organisation and the people working there.

At this stage of the project we already see an effect in better and more available information, while the time and money saving effect hopefully will come at a later stage.

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Total LCC and Sustainable Construction

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1. INTRODUCTION

This paper examines how to best achieve sustainable development in construction.

2. WHAT IS SUSTAINABLE DEVELOPMENT?

"Sustainable development is a matter of satisfying the needs of present generations without compromising the ability of future generations to fulfil their own needs" [Brundtland report, "Our Common Future", 1987]. Sustainable development means sustainability not only ecologically (= environmentally) and economically but also socially and culturally.

Lately in the EU and UN, an expression *the three pillars of sustainable development* is often used; the pillars are said to concern economic, environmental and social development. Yet, they *should read economic, environmental and societal* (= social, cultural, ethical etc) development. The importance of the omitted cultural issues is recognised eg in CIB's "Agenda 21 on sustainable construction", and numerous other documents and declarations.

As per Rio 1992, countries should prepare national strategies on sustainable development in 2002 latest. Only few countries have provided something meaningful (eg SE, DK, DE, AT, GB) with proper objectives (what, when) and action plan (how, who, financials, monitoring).

3. WHAT IS SUSTAINABLE CONSTRUCTION?

3.1 Recent development

For *sustainable construction* CIB W82 (OT a member) proposed the following definition in 1998: "The creation and responsible management of a healthy built environment based on resource-efficient and ecological principles". This *definition is not satisfactory, as it leaves out economic and societal issues* completely.

In its report "An Agenda for Sustainable Construction in Europe" completed in June 2001, an industry-led working group for Sustainable Construction with participants from the European Commission, Member States and Industry (OT a member) and working for the EC DG Enterprise's agenda on the Competitiveness of the Construction Industry recommends that "All member states and accession countries should be encouraged to draw up and publish plans and programmes for sustainable construction". Within the EU, Finland, Germany, Ireland, Luxembourg, the Netherlands and the UK have such papers of various qualities.

Last autumn, a new task group (OT a member) was established in the EC Enterprise to "Draw up recommendations and guidelines on Whole Life Costing - WLC of construction aimed at improving the sustainability of the built environment". The group tries to find models for practical application of sustainable construction based on Net Present Value – NPV of economic and environmental factors. Societal factors (social, cultural, ethical etc) were unfortunately left out.

3.2 Could this be sustainable construction?

The ways in which built structures are procured and erected, used and operated, maintained, repaired and refurbished, and finally dismantled (and reused) or demolished (and recycled), constitute the complete cycle of sustainable construction activities.

Minimise the use of materials, energy and water, and mobility. (NL: factor 20).

Building products should be reusable and materials recyclable. Design for long service life (and durability) is superior to design for reusability. Reusability is superior to recycling, and recycling is superior to waste disposal.

In sustainable construction, reusability and the ease of changeability are necessary product properties, in particular for modular products and systems with different service lives.

4. WHY SUSTAINABLE CONSTRUCTION IS IMPORTANT?

In advanced European vocabulary "construction" is considered to cover the entire value chain of develop/own, design, manufacture, construct, recycle a building, infrastructure or other constructed assets. Today in Finland and elsewhere, a new expression *Construction and Real Estate Cluster - CREC* has been taken to use to cover all activities directly related to construction and real estate (buildings, infrastructure and other constructed assets = 60-70% of the national wealth). Compared to the above, *CREC covers the whole life of a building*, hence additional activities concern running (or operating...) the building, which more often is done by facilities management. According to ISO 15686 “Buildings and constructed assets – Service life planning”, running a facility covers the following activities/costs:

Operating cost = The cost incurred during the normal operation of a building or structure, or a system or component including labour, materials, utilities and other related costs over the life cycle.

Maintenance cost = The cost incurred in conducting the combination of all technical and associated administrative actions during the service life to retain a building or its parts in a state in which it can perform its required functions.

Repair costs = The cost incurred in returning a building or its parts to an acceptable condition by the renewal, replacement or mending of worn, damaged or degraded parts.

Refurbishment cost = The cost incurred in rehabilitation (deprecated), renovation (deprecated) and modification and improvements to an existing building or its parts to bring it up to an acceptable condition.

A reason to this approach is the fact that major contractors are moving from plain construction towards taking care of the building/facility for its whole life. Also public-private partnership projects (BOOT, PFI; toll roads & bridges, schools, prisons etc) require this approach.

In 2001, VTT (a leading construction/CREC research centre in Europe) made a study about CREC in Finland[1]. Some interesting findings are repeated below for the year 2000:

[1] Different clusters have been studied in most EU countries during the past ten years. In Finland, cluster studies cover practically all the activities of society.

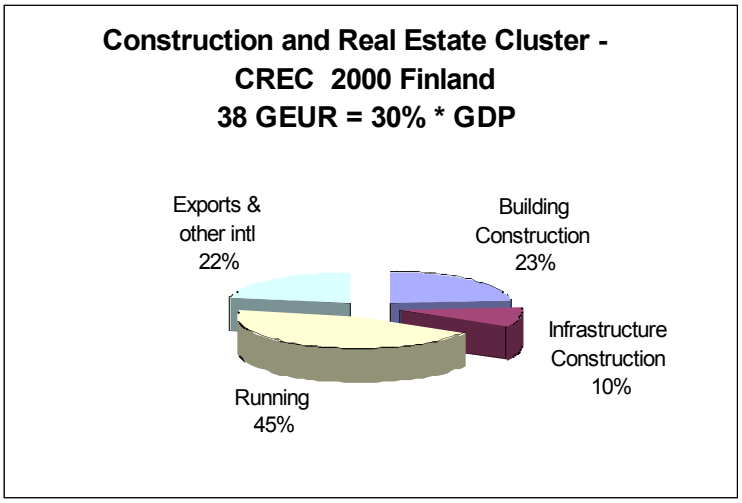

Figure 1 Construction and Real Estate Cluster - CREC, in Finland, year 2000.

While in Finland construction represents 10% of GDP (or 12% if repairs & refurbishment are counted in), CREC represents 30% of the same GDP. Accordingly, *in the EU construction represents 11% of the total GDP, and CREC nearly 30% of the same GDP!*



Figure 2 CREC Running Costs in Finland, year 2000.

Here it can be seen that in Finland heating (17%), repairs & refurbishment (16%), maintenance (15%) and cleaning & waste (14%) are the highest cost activities.

VTT also has written an initial definition for CREC: *CREC serves its customers through providing, developing and maintaining the built environment and related necessary services*. Also, as earlier said, CREC = develop/own, design, manufacture, construct, run/operate, recycle a building or other constructed assets.

All the aforesaid proves that *construction and CREC are big, thus their sustainability is most important for whole society!* Also their environmental impact is big: buildings consume about 40% of total energy and account for 30% of CO_2 emissions.

5. WHAT ARE LCA AND LCC (or WLC)?

Derived from ISO 14040: In construction, environmental life cycle assessment - LCA is for assessing the total environmental impact associated with a product's manufacture, use and disposal and with all actions in relation to the construction and use of a building or other constructed facilities. LCA does not address the economic or social aspects.

Derived from ISO 15686: Life cycle costing - LCC is a technique which enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors both in terms of initial capital costs and future operational costs. [UK expression Whole life costing - WLC is gaining some support separating Life Cycle - LC from Whole Life - WL: WL can cover several different (usage etc) LCs of a building; also, the LCs of various replaceable components/systems are much shorter than the WL of a building.]

6. CAN LCA AND LCC BE PUT TOGETHER?

LCA has been very much studied. The results may be used to create regulatory requirements, offer incentives and determine rating/scoring systems to help decision-making. *LCA does not give you any figure in money*.

LCC gives you figures in money for any present and future costs as required. Thus, in the case of tenders, considering construction cost as usual plus LCC calculations together with scoring, you have to be able to calculate *a total = money + points!* No existing related software gives any proper solution to this equation. Thus, the initial result is no, *LCA and LCC cannot be put together*.

Yet, it is my intention to further study this equation on a case study project in Finland (a newly completed office building for adaptable rental use, 10,000 m^2 floor area) using LCC and some LCA-related method (perhaps including a proposed methodology that permits contract award to the Economically Most Advantageous Tender – EMAT, developed by a task group working for the EC DG Enterprise's agenda on the Competitiveness of the Construction Industry, and published in July 2001). It is also my intention to study the suitability of the newest software for multi-objectives and multi-criteria decision making using Monte-Carlo simulation (@Risk, Crystal Ball) and decision trees (Precision Tree, Logical Decisions).

7. TOTAL LCC & SUSTAINABLE CONSTRUCTION

7.1 Total LCC

To overcome this LCC+LCA problem, I try to look at it purely arithmetically. In the book "Construction Can!" published by arrangement of ENCORD in 1998, I introduced a fresh approach to LCC to cover not only the initial capital and (direct) future costs of a building/facility but also occupational, locational, environmental and societal factors, as shown below.

> *Total LCC = Acquisition (a total of all initial capital costs) + NPV [Building (operating + maintenance + repair + refurbishment + disposal - residual value) + Occupation (occupational LCA factors) + Mobility (locational LCA factors) + Environment (environmental LCA factors) + Society (societal LCA factors)]*

NPV = Net Present Value of the accumulated future costs (C) over a certain period of time (t), eg 30 years (N), at an agreed discount rate(s), eg 6% pa (i), dependant on prevailing interest

and inflation rates. NPV is calculated according to the following formula, and can be done with eg MS Excel (up to 29 years / 97 SR-2).

$$NPV = \sum_{t=0}^{n} \frac{C_t}{(1+i)^t} \quad (1)$$

Building (operating + maintenance + repair + refurbishment + disposal - residual value) refers to the future costs of all the different activities necessary to run the building or other constructed facility during a certain period of time, eg 30 years. The above-mentioned principal activities are as defined in ISO 15686. In the NPV formula, there are costs caused by these activities. Period is determined as per the planned/ongoing activity and can be whatever. This is also true for other factors below, of course.

Occupational factors refer to health, comfort, productivity, safety and security of a building (eg office). It is here important to realise the relationship of different accumulated costs for an office building with eg 30-year ownership (source: The Royal Academy of Engineering, GB):

1 : 5 : 200
1 = acquisition, 5 = building operating and maintenance, 200 = business operating costs → here the biggest benefits are easiest to achieve through better comfort and productivity → good indoor environment/climate/air.

Mobility, hence locational factors refer to the location of a (industrial, commercial, office, school etc) building. We should calculate LCC not for the building alone but also its location in relation to incoming material and outgoing product flows as well as to employees' daily commuting or school children's daily transport, ie the mobility the building is causing.

Environmental factors refer to different environmental impacts that various materials and actions cause; environmental profiles. Environmental factors are, however, hard to come by and need a lot of RTD at European and international levels to define their features and properties and, perhaps, to give them generally accepted values. Here the already existing LCA studies and environmental construction technology reports give a good starting point.

Societal factors finally need to be taken into account. This area is very little covered so far.

7.2 Can Total LCC Help Us towards Sustainable Construction?

In the Total LCC equation, acquisition cost plus NPV of building, occupation and mobility costs (case-dependant) are in direct interest of the owner and user. Thus we can look how much he/she can gain in investing for lower future costs.

Table 1 NPV calculations at different discount rates.

NPV = Net Present Value of accumulated constant 100EUR annual costs over a 40-year period and of the cost in the 40th year, at different discount rates (rounded figures)

Discount Rate	*NPV (40 a total)*	*NPV (40th a)*
9% "business economy"	*30% ¬ 1,100EUR*	*3% ¬ 3EUR*
6% "state economy"	*40% ¬ 1,500EUR*	*10% ¬ 10EUR*
3% "national economy"	*60% ¬ 2,300EUR*	*30% ¬ 30EUR*
0% "natural economy"	*100% ¬ 4,000EUR*	*100% ¬ 100EUR*

The rate of return available through LCC considerations is usually lower than that offered by alternative long-term investment: as annual return, 25% stock market (-90% for dot.coms ← high risk), 15% business ROI/ROC (risk), 6% bonds, 3% bank account. It may be claimed, however, that future LCC costs will be increasing due to higher energy prices and new environmental and other regulatory requirements. This development will rise the calculated return and *may enable market-driven LCC considerations*.

Where are we today: Acquisition cost governs! LCC is up and coming, yet today mainly for future energy costs only. The rest must be done!

This Total LCC approach I intend to study further theoretically and on two test cases, a newly completed office building for adaptable rental use, 10,000 m^2 floor area, Finland (mentioned earlier) and a newly completed hospital, 45,000 m^2 floor area, the UK.

8 EUROLIFEFORM

For LCC to become widely accepted, concerns about uncertainties in forecasting must be overcome: performance of building, products, systems; costs; occupational, locational, environmental and societal factors. A new European RTD project *EuroLifeForm is to advance a probabilistic approach on LCC* in construction, with a budget of 3.8 MEUR in 2001-04. Taylor Woodrow (GB) is the coordinator and Villa Real (FI) the originator and a major partner, plus partners from eight countries. The project aims to develop a design methodology and supporting data, using a probabilistic approach. It primarily addresses technological performance and cost issues but environmental impacts and other factors are also considered. The deliverable will be a generic model for LCC and Performance - LCCP, in a software format, good for developers and designers.

Here the newest theories and software are used; particularly multi-objectives and multi-criteria tools for decision making using Monte-Carlo simulation (@Risk, Crystal Ball) and decision trees (Precision Tree). These programmes are capable for complex decisions, where there can be trade-offs among competing objectives. They also include probability, risk and sensitivity analyses. And they are presented on MS Excel spreadsheet.

Data and information is collected in all eight member states; generic and on ten case studies. Studies carried out so far cover design decision mapping, performance data as per Unified Classification for the Construction Industry - Uniclass classification, cost data of acquisition/construction as per Uniclass, and environmental data.

Further information about EuroLifeForm is available on www.(...to be concluded).

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Climate change - adaptation, mitigation and the search for integrated response strategies.

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1. INTRODUCTION

The impacts of climate change on human society are pervasive and multi-faceted. Because of its long physical life and the fact that it is directly responsible for around 50% of CO_2 emissions from industrialised countries, the built environment represents one of the most important sectors of the economy in this context. Much of the work on development of responses to climate change is based on a clear distinction between adaptation and mitigation strategies. This paper argues that this distinction is unhelpful, particularly in the context of the built environment, where there are potentially significant interactions between the two classes of measures. Given the radical nature of the demands of climate change, and the limited capacity both of the construction industry and wider society for fundamental technological and social change, it would appear to be essential that such responses are integrated both with each other and with other agendas for change.

2. ADAPTATION AND MITIGATION OF CLIMATE CHANGE

Climate change is a global phenomenon caused primarily by the emission of CO_2 from the combustion of fossil fuels. Mitigation of climate change requires CO_2 emissions and other greenhouse gases to be cut. A vigorous approach to mitigation, implemented globally, would reduce the temperature rise in 2100 by 2K or more, but its biggest impacts would be in the 22nd Century (IPCC 2001). The effects of climate change are however already apparent and in some areas will become significant by the middle of this century. It is obvious that even an optimistic view of efforts to mitigate climate change does not remove the need to adapt to it. Neither, however, does the possibility of developing and implementing adaptation strategies undermine the case for mitigation, which is based on the precautionary principle and the risks that flow from unconstrained climate change, particularly towards the end of this century. To put it simply, both adaptation and mitigation appear unavoidable.

The reductions in emissions of carbon dioxide and other greenhouse gases required to stabilise the atmosphere and control climate change are large. This issue has been considered at national level in a number of countries including Germany (Bundestag 1991), Denmark (Danish Ministry of Energy & Environment 1997), the Netherlands (RIVM 2000) and, most recently, the UK (Blundell et al 2000). Estimates for the reduction in emissions required in these countries range from 60-85% by the middle of the century. It is likely that even larger reductions would be needed by the end of the century as the ability of the oceans to absorb CO_2 declined, following the reversal of the trend of the last two centuries.

The whole of these reductions would not need to be achieved by end-use sectors such as the built environment. Significant improvements in the carbon intensity of energy supply systems can be expected - in the UK a technically conservative assumption would be that by 2050 the

carbon intensity of delivered electricity will have fallen by more than a factor of two, bringing it down to the level of natural gas[1]. But such developments will be offset by large increases in stocks of buildings, by improving internal comfort, by ever higher levels of IT provision[2], by increased demands for cooling stemming directly from the effects of climate change and by as yet unanticipated demands for energy[3]. Reductions on the scale needed cannot be achieved without the participation of the built environment, since this sector accounts directly for around 50% of current emissions and indirectly for an even larger proportion.

It seems unlikely that sustained, absolute reductions in sectoral energy use can be achieved without fundamental changes in the planning, construction, management, maintenance and, ultimately, the disposal of buildings and other infrastructure. These changes will require, in turn, deep shifts within the wider political, social and economic environment. In those countries that adopt such policies, climate change mitigation is likely to become one of the key drivers of change in the construction industry (and all other economic sectors) over the next two to three decades.

3. CLIMATE CHANGE IMPACTS AND ADAPTATIONS

The primary measure of climate change at the global level is temperature. Working Group I submission to the IPCC Third Assessment Report (TAR) (IPCC 2001) shows global mean temperature rising 2.0 - 4.6K by 2100, on central assumptions about climate sensitivity, for a range of emissions scenarios. TAR describes scenarios that span the whole of this range, resulting in stabilisation of atmospheric CO_2 at concentrations from 1000 down to 450 ppm[4].

Detailed work at the regional level establishes a wide range of direct physical impacts on the built environment. In the UK these include coastal inundation, higher maximum wind speeds and changes to patterns of rainfall leading to significantly greater risks of rain penetration and flooding (Hulme & Jenkins 1998 and Hulme et al. 2002). Impacts of climate change are however not limited to direct physical impacts on buildings or infrastructure. A variety of indirect impacts can be identified, including:

- changes in the insurance market, regulatory environment and property markets in response to changing perceptions of future risk;
- physical changes to existing systems or components to offset the increased risk that would otherwise result from climate change;
- new systems or approaches to construction, again designed to offset direct impacts of climate change;
- changes in regulatory environments and design codes;
- development of planning systems to reduce future exposure to enhanced risk;
- development of social or economic mechanisms to compensate individuals who would otherwise lose out either from climate change or from the implementation of adaptations –

[1] Such a performance could in principle be achieved now by a system in which half of all electricity was supplied by gas-fired combined cycle power stations with a thermal efficiency of 50%, with the rest coming from carbon-free sources such as renewables.

[2] From the viewpoint of the majority of individuals, the whole IT revolution has essentially taken place in the last quarter of a century. The obvious difficulties inherent trying to predict developments between now and 2050 – a period twice as long - has not prevented some from trying (Kurzweil 1999).

[3] One of the more thought-provoking developments of the last decade has been the rapid growth in the practice of heating outside spaces. This has been stimulated by steadily rising wealth and falling cost of heat in most industrialised countries. The author is not aware of any country in which this development is controlled by building regulation or any other form of regulation.

[4] 450 ppm is roughly 1.64x the pre-industrial concentration and 1.25x the current concentration of CO_2.

eg. from decisions to give up land that is at risk from coastal inundation or erosion or to re-assign land previously earmarked for development.

The point about the above list is that adaptations to climate change will themselves impact on individuals, groups and whole societies. It can also be argued that impacts of policies to mitigate future climate change should be categorised as indirect impacts of climate change. While specialists may attempt to differentiate clearly between mitigation and adaptation and between direct impacts and the impacts of responses, such distinctions may appear to non-specialists to be academic.

The above list of indirect impacts was originally compiled in the context of a strategic review of climate change impacts on the UK built environment (Lowe 2001b). One of the failings of this study was to consider the UK in isolation from the rest of the world and the built environment in isolation from other systems. From a broader perspective, climate change may result in displacement of human populations through direct impacts on environments and agricultural systems, particularly but not exclusively in the Third World. Such displacements would impact on the built environment through processes of migration (both within and between states) and urbanisation and, in some regions, may dwarf other categories of impact.

4. SYNERGY OR CONFLICT?

Climate change mitigation and adaptation have significantly different characteristics and impose different requirements on stakeholders. Major components of adaptation strategies will be geographically fine-grained, dealing with risks such as riverine flooding and coastal inundation. Mitigation strategies are in contrast systemic, focusing on technological changes to energy supply and end-use systems and that are valid at the national, continental and in some cases global scales[5]. Benefits of mitigation are long term and global, with no direct benefits to countries, companies or individuals involved[6]. The implementation of mitigation therefore depends on the political task of constructing national and international consensus for action and of implementing systems such as energy or carbon taxation which convert long-term, global, external benefits into privately realisable benefits. The fact that the benefits of adaptation accrue at all scales – national, regional, municipal, corporate and private – make it in principle easier to mobilise support for programmes of adaptation than for effective mitigation.

There are nevertheless significant interactions and powerful potential synergies and conflicts between adaptation and mitigation measures – see Figure 1. One of the best examples of synergy is the fact that highly insulated and airtight buildings with carefully considered glazing and built form, carbon-efficient building services, information technology and domestic appliances, simultaneously achieve up to a 90% reduction in carbon emissions under current climatic conditions, and:

- minimise peak summertime temperatures and future cooling requirements;
- guard against the risk of future higher energy prices;
- minimise the risks from both expected and unexpected changes in climate – eg the possibility of much lower winter temperatures that may arise in Western Europe from changes in thermohaline circulation in the Atlantic.

[5] Examples include electricity-efficient IT systems, fans, electric motors and domestic appliances.

[6] There may well be large first-mover and other indirect benefits for countries that develop low carbon technologies and infrastructures first. But these benefits are second order in that they do not derive from reductions in the rate or magnitude of climate change itself.

Paradigm examples of such buildings include the prototype passive houses at Darmstadt Kranichstein (Feist 1994) and the Elizabeth Fry Building at University of East Anglia (Probe 1998). Interestingly, such buildings are likely to perform well in a wide range of climates.

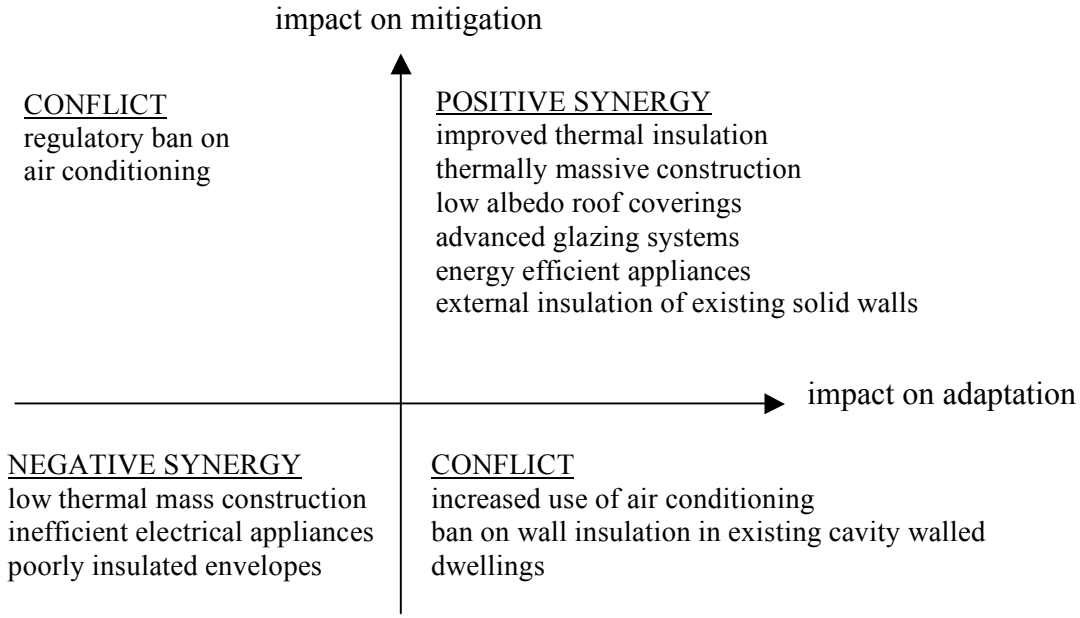

Figure 1 Examples of interactions between climate change mitigation and adaptation strategies.

The most straightforward example of conflict is the increased use of air conditioning in response to hotter climates – this appears to be the default response in most countries[7]. An important example in the UK is the possibility of severe regional constraints on the use of cavity wall insulation in both new and existing houses in the UK (Graves & Philipson 2000). This possibility arises from the expected increase in the incidence and severity of driving rain in the UK over the next 50 years. Unfortunately, the thermal insulation of existing cavity walls represents one of the most important remaining energy conservation opportunities in existing UK housing. The loss of this option would significantly increase future CO_2 emissions from existing housing, increase the risk that the inhabitants of these dwellings will suffer from fuel poverty.

The imposition of regional restrictions on the insulation of existing cavity walls is an adaptive response, which falls into the fourth quadrant of figure 1 – a positive adaptation with negative impacts on mitigation. A variety of alternatives to this response exist. These include the development of remedial systems, including low cost and reliable insurance systems, to overcome problems of water penetration where these occur. Such alternatives would fall on the positive portion of the horizontal axis – positive adaptations with no impact on mitigation

[7]Responses to climate change can be categorised as **coping** (eg. putting up with higher summer temperatures), **default** (eg. fitting air conditioning in existing and new buildings), and **early-and-strategic** (adaptations that are planned and implemented in a timely and strategic fashion) (Lowe 2001b).

– or into the first quadrant if they made it possible to extend the range of cavity insulation beyond that currently deemed feasible.

Second quadrant conflicts also exist. The example given in figure 1 has often been mooted in the UK and elsewhere as an approach to reducing energy use. A related example is the simplistic reliance on the strategy of naturally ventilating buildings as an approach to reducing energy use. Such buildings are already near the limits of their performance envelope in many parts of Europe and North America. Significant increases in summer design temperatures (Brabson, 2002) coupled with continued increases in expectations on the part of building users means that artificial means of cooling are likely to be seen as essential within a few decades. But naturally ventilated buildings are likely to be more difficult to retrofit than mechanically ventilated buildings. There is a risk that such buildings buy modest energy efficiency gains in the short term at the cost of potential inflexibility in the long.[8]

Both mitigation and adaptation strategies interact with other political, economic and technical agendas. In each case, similar analyses to that presented above can be conducted. An example of such a third agenda is the problem of fuel poverty. Long term strategies to mitigate fuel poverty, by raising the thermal and energy performance of the housing stock, are clearly synergistic both with mitigation and adaptation. But a number of short term measures to mitigate fuel poverty conflict with strategic responses to climate change. Measures to reduce energy prices clearly fall into this category. So, also, do programmes aimed at achieving modest upgrades to the thermal performance of existing dwellings, where these close off opportunities for the radical upgrades required for climate change mitigation.

CONCLUSION

Without minimising the sometimes far-reaching nature of the demands of adapting to climate change, it appears likely that where the demands of mitigation are taken seriously, they will become the dominant driver for change in the built environment over the next few decades. This conclusion is, however, not universally acknowledged. Current responses to climate change appear to vary widely across EU member states and comparison of the approaches being taken reveals clear differences in priorities, with for example, much greater emphasis being given to the long-term mitigation of climate change in Holland and Germany than in the UK. In the first two countries, adaptation appears to be predominantly concerned with the far-reaching demands of a radical mitigation agenda, rather than with the direct impacts of climate change (RIVM 2000, BVBW 2001). Despite the recent publication of the Royal Commission report on climate change (Blundell et al 2000) and the Performance and Innovation Unit's energy review (PIU 2002), the UK Government has still not formally committed itself to a programme of mitigation measures beyond the requirements of the Kyoto agreement. Key institutional developments – UK Climate Impacts Programme (UKCIP) and the Tyndall Centre – are focused mainly or wholly on the development of adaptation strategies.

As the examples presented in this paper have shown, mitigation and adaptation are interdependent. The development of integrated climate change response strategies, based on the systematic identification of synergies and conflicts between mitigation and adaptation measures are likely to have a number of benefits, including:

[8] The conflation of energy efficiency with natural ventilation is a widespread but unfortunate error. Mechanical systems do, unfortunately, make it possible to rescue incompetently or irresponsibly designed buildings at the cost of high energy use. But in most categories of building and many climates, well-designed mechanical systems in well-engineered buildings outperform natural ventilation in terms both of energy use and air quality.

- avoiding the inadvertent closing-off of potentially valuable innovations and changes
- minimising the number of separate measures that need to be implemented and making the best use of industry's and society's capacities to devise, implement and absorb change
- increasing the economic viability of measures that fall in the first quadrant of figure 1.

Integrated approaches to climate change are likely to be more successful at achieving both goals of adapting to and mitigating climate change. Developing such approaches will be one of the most interesting and difficult tasks facing the built environment research community over the next decade.

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Introduction of environmental management in an organisation that develops, builds and manages property for government purposes: a process of change

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1. "GREEN STATE" – A PILOT PROJECT LAUNCHED BY THE GOVERNMENT

The pilot project "Green State" was launched in September 1998. The aim of the project was to gain experience in finding the best ways to integrate environmental principles into government organisations. The project's primary objective has been to reduce the environmental impact in a representative sample of government activities by testing various systems and measures. The Directorate of Public Construction and Property (Statsbygg) was one of a total of ten different organisations that took part in the three-year project. The project was commissioned by the Ministry of Labour and Government Administration (AAD) and the Ministry of Environment (MD), and the Norwegian Pollution Control Authority was responsible for coordinating the project.

Statsbygg, which manages 2.1 million m^2 of building stock, is the Norwegian government's construction supervisor and consultant in building and property matters and develops government properties. Statsbygg is a major player in the Norwegian building and property sector with a staff of about 650 civil engineers, architects, planners, lawyers, economists and building operations managers. Statsbygg is a directorate under the Ministry of Labour and Government Administration.

Statsbygg belongs to a conservative business sector with a natural inclination to resist rapid change. We had no greater interest in or expertise on the environment than any of the other players in the sector. At the start of the project and during its implementation, the organisation has come under a great deal of pressure, some of it negative, partly as a result of prolonged negative media coverage and an extensive reorganisation process.

In spite of this shaky start, the project can be considered a success: we have increased our environmental expertise and generated greater awareness and commitment among many employees to an extent that would have been inconceivable as recently as two years ago. In the final year of the project, Statsbygg won the Økobygg Expo's Environmental Prize for 2001 for having "promoted the environment as a key element of its strategy and for being a standard-setter in the industry."

This paper presents the results and experiences, both good and bad, of Statsbygg's involvement in the "Green State" project.

2. HOW WE APPROACHED THE PROBLEM

2.1 Environmental Policy and Environmental Action Plan

We started out by establishing the first elements in the environmental management cycle in the way that it was implemented in the official eco-management and audit scheme (ISO 14001, EMAS). This scheme consists of drafting environmental policy and environmental goals, an action plan for achieving these goals, implementation of the plan and finally reporting the results. When introducing environmental management it is important to arrange matters in such a way that there will be steady improvement. This entails the establishment of indicators by which improvements can be measured. Reporting and measuring the results make it possible to adapt or add goals and measures so that the environmental results can be steadily improved.

In 1999, we began by surveying the environmental impacts that derived from our activities. This survey formed the basis for formulating Statsbygg's environmental policy, which consists of seven primary goals and a concrete environmental action plan. The environmental policy entails that Statsbygg shall:

- be a centre of excellence, generating environmental initiatives in the building and property sector.
- strive to make its own activities more eco-efficient.
- advise and encourage its clients and customers to make environmentally correct choices in their building and property matters

In order to achieve these ambitions, we have defined seven primary goals for both our short and long-term efforts:

1. Develop environmental expertise throughout the whole organisation.
2. Incorporate environmental principles and requirements into all phases of the construction projects, and likewise into the management, operation and maintenance of our buildings.
3. In accordance with the goals of sustainable development, limit our environmental impact by taking steps to promote:
   - energy efficiency and energy flexibility
   - reductions in the use of noxious and hazardous substances
   - eco-friendly use of materials, e.g. repair instead of replacement, more recycling and/or reuse and less disposal of waste in landfills
   - efficient use of space
4. Prevent the loss of or damage to cultural monuments that warrant protection.
5. Help develop policy instruments, tools and skills that promote the choice of eco-friendly solutions.
6. Practice an environmentally aware purchasing policy.
7. Conduct eco-friendly operations on its own premises.

Each of these primary goals was accompanied by concrete measures and tasks, and taken together these constitute our environmental action plan. The responsibility for implementing these measures was delegated to the individual departments and line managers. In the autumn of 1999, the top management approved an environmental policy for Statsbygg and a first generation environmental action plan.

In the spring of 2001, the top management approved a new environmental action plan for 2001-2003. This environmental action plan has been the object of a thorough round of

hearings, wide-ranging discussions and a quality review throughout the whole organisation for almost three months. The technical units and key staff in Statsbygg have recommended the measures that have been drafted into the plan. Behind every single measure that has been proposed in the plan lies a great deal of work, skill and commitment from our staff. In the words of one of the contributors, "We who work with this on a daily basis have put a great deal of effort into this text, and we know what we are talking about! We have made recommendations only after satisfying ourselves that they would be relevant, popular and practicable." The environmental action plan should be the object of regular evaluations and revisions, e.g. with regard to the progress and resource consumption in the various departments.

2.2 Organisation of the project and use of resources

The work has been organised as a project with its own project manager and project organisation, which has been modified many times since the start of the project. The project manager reported through the director in his own department to the managing director.

Participation in "Green State" has been voluntary and no funds have been allocated for the implementation of the project. It was assumed that each of the participating organisations would meet the necessary expenses and time requirements on its own initiative. In Statsbygg, the project has had a separate budget. Over the entire three-year period, we have spent NOK 2.1 million and committed a total of 3.9 man-years of our own efforts. The man-years only reflect the efforts of the project manager and a few key staff on the project team, which consisted of anywhere from two to five members during the project period. In reality, many more employees have chipped in, but in those cases as an integral part of their daily work. Between NOK 500,000 and NOK 1 million have been spent each year to support the implementation of a number of concrete measures in the environmental action plan, when external expertise was required. Funds were also spent on competence building and publicizing measures.

2.3 Follow-up of the environmental work

The follow-up of the environmental work has been a difficult task. Different units gave the work on the measures in the environmental action plan different priorities and followed it up with varying degrees of commitment. These efforts also varied in relation to the situation in the organisation, which at times was under considerable pressure because a major ongoing reorganisation process was underway. The follow-up was supposed to go through the line managers. In practice, however, it was the project manager, supported by a few key resource persons interested in environmental work, who provided the necessary incentive and held people to their commitments, especially in the "difficult" periods.

At the same time, there has been a great deal of pioneering work in some of Statsbygg's units in important urban development projects, such as Pilestredet Park and the reuse of Fornebu Airport. Pilestredet Park is an area in the heart of downtown Oslo on the site of the old National Hospital, Oslo, which is being developed into an attractive commercial and residential neighbourhood. At Fornebu a large area is being converted to residential, commercial and recreational uses, after a former International airport was closed down. In these projects, the concept of sustainable development has been adopted and made into an essential part of the strategy for how to succeed with these projects. One main goal was to pay just as much attention to environmental criteria as to functional, technical, aesthetic and economic criteria when weighing the overall importance of different interests. In doing so,

we had to overcome at least as much resistance in the attitudes encountered in certain parts of the organisation as in the work on the "Green State" project.

3. RESULTS

It quickly became evident that the "Green State" project had just as much to do with the demanding process of changing attitudes as it did with the practical details of environmental management. Generating enthusiasm has been difficult. The project touched upon the very core of our professional activities and many people had to change their professional opinions. Others did not take the effort seriously and regarded it as nothing but a lot of grandiose words and testimonial speeches that would quickly expire on its own.

After the first year, people began to demand results. Although we managed to implement most of the planned measures in accordance with the environmental action plan, it was not as easy to point to achieved targets and comforting diagrams. On the contrary, according to the project manager, the most important result was not measurable. To put it rather bluntly, the biggest success after the first year was that people had stopped laughing or sighing when environmental considerations were mentioned."

Whereas the drafting of environmental policy and the first environmental action plan met with minimal interest from much of the organisation during the first year, the opposite has occurred after the second year. A surprisingly large number of employees were involved in the process of preparing the environmental action plan for 2001-2003, which resulted in an extensive professional debate. There was still perceptible resistance, but this time it was of a different nature: healthy scepticism and critical professional interest. Something had obviously changed.

Now, after three years and the completion of the project, we see new trends: more and more people are taking the initiative and trying to specify requirements for environmental quality in the specific projects and tasks in which they are involved. Simultaneously at the management level, they are discussing a formalization and professionalisation of the environment as a new target area in Statsbygg.

Many of the measures have been mainly process-oriented. Here are some examples of what we have achieved:

- greatly increased environmental expertise in the organisation
- started systematising and upgrading environmental requirements in design specifications, performance criteria and building programmes
- integrated environmental requirements into new goals for building programmes. Methods and tools have been devised, which have also been utilised in project competitions.
- a number of measures promoting increased energy efficiency in the existing building stock and in new buildings have been implemented. The average energy consumption for Statsbygg's total stock of properties has been below the Ministry's requirement of 220 kWh/m^2 in recent years and has undergone a declining trend.
- started surveying the extent of PCB-contaminated lighting fixtures, which must be refurbished in our stock of buildings erected prior to 1980.
- tested on our properties and further developed a new environmental accounting system for the operation and maintenance of buildings. An implementation of this system is being planned.
- developed guidelines for evaluating building materials with an environmental declaration (together with the Norwegian Building Research Institute and the EcoBuilding

programme). In many projects, we have set requirements for the selection of building materials with an environmental declaration. The guidelines simplify the interpretation of the environmental declaration and make it easier to select environmentally correct products in the building supplies industry.
- documented results achieved through our first official environmental report.

4. WHAT WENT WELL AND WHAT WENT NOT SO WELL

The most important positive change occurred about halfway through the project period, when the project management implemented an extensive training programme. Nearly 200 employees have taken part in various courses, adapted to the individual target and professional groups. The concept of the environment was specified through advanced study in topics such as noxious and hazardous substances in existing buildings, environmental requirements in tendering documents, selection of environmentally correct materials, waste disposal on the construction site, and the EcoProfile method. The staff's reactions and remarks such as, "I didn't realise that this environment business could be so concrete!" or "How is it possible that we have not known about the PCB problem in older buildings?" and to the project manager, "I think you have made a lot of new friends today," makes it clear that an important change of attitude had occurred. One of the people who attended class together with his employees was the director of the property division, who later became the Director General of Statsbygg.

We can be satisfied with having integrated environmental requirements into our building programmes and further developed tools for environmentally correct planning and design. These are being put to use in more and more construction projects – Oslo's new Opera House, which is now being designed is just one example. For property managers and system operators the transition from words to action was probably the quickest; e.g. they are already underway with an extensive survey and refurbishment of PCB-contaminated lighting fixtures in the buildings that they manage.

On the other hand, we did not complete the systemization and upgrading of environmental requirements in the design specifications and performance criteria. Even though they have managed to recover fully 97% of the demolition waste in the Pilestredet Park project and can boast of excellent results in the handling of production materials and demolition waste in the Fornebu project as well, we have not yet achieved sufficient, systematic control over waste disposal in general in all of our building projects. One widespread view is that one of the obstacles to our efforts to improve the environment is a lack of information and guidelines for determining the relative importance of environmental and economic criteria. For Statsbygg, the potential economic savings that derive from environmental measures will mainly benefit our tenants. Statsbygg makes investments and thereby incurs costs that result in environmental improvements, but it is the tenants who reap the benefits of lower expenses, e.g. as a result of lower energy consumption.

Strong support for the project in the top management during its three-year existence, regardless of the reorganisation and replacement of the Director General, must be regarded as the project's greatest privilege and strength. On the other hand, it has been difficult to gain the same support at the middle-management level. The situation has improved somewhat in the past year when the project got its own reference group. This group, which was composed of middle managers and some of the top management, provided administrative support for the project.

5. WHAT DID WE LEARN AND HOW TO SUCCEED

What would we do differently if the project started today and we knew what we know now?

- Got started much earlier with an intensive effort to improve environmental knowledge, always closely linked to specific problems in the relevant technical field and day-to-day work of the staff. We have learned that expertise on the environment is the key to greater insight, interest and a willingness to do things differently than they have traditionally been done
- Started with a few simple, but very specific measures that give visible, relatively quick – and preferably also economically profitable – results in order to increase motivation
- Made a much greater effort to establish a good network, close ties and stronger support among the middle managers.

Here are some general recommendations for how to succeed with a similar process:

- Strong support from the top management is probably the most important condition for success.
- Remember that this involves a process of changing attitudes, and that you will always take longer and encounter more resistance than you expect. The project manager will have to show a great deal of perseverance and commitment
- Be as specific as possible every time you are going to communicate something in connection with efforts to improve the environment! Avoid using words such as environment and environmental considerations unless you can specify what you are actually talking about in the next sentence
- A good environmental policy and approved environmental action plan with the "correct" goals and measures are no guarantee of success. Involve as many co-workers as possible and find support and a good network throughout the organisation, particularly at the middle management level.
- Have high ambitions, but let the measures be realistic and doable. The economic cost of implementing these measures should always be evaluated. Do not try to implement everything at once: selection of priorities is an important catchphrase!
- Make it easy for the staff to take steps to improve the environment, and make sure that the environmental requirements that have been specified are followed up! Requirements must be consistently adhered to throughout the process all the way to the finished product.
- Good examples increase motivation and competence! The pioneering work and experiences from important environmental projects, such as Pilestredet Park and Fornebu will have ripple effects. For instance, experiences with environmental follow-up programmes, such as management tools are now being used in connection with the planning, development and sale of other properties, such as the Vestbane site in the middle of downtown Oslo and the design of the new Oslo Opera House.
- Finally, make use of your ability to motivate and generate enthusiasm! Efforts to improve the environment ought to be fun, and not just "correct".

6. WHAT LIES AHEAD

One of the key objectives of the "Green State" pilot project has been to gain experience that can later be further developed and transferred to other government departments and organisations. The government is now making plans to introduce environmental management in all government organisations as an integral part of their activities by 2005. The ministries are leading the way to set a good example and have already commenced this work in 2002.

After the close of the "Green State" project, Statsbygg's top management has declared that they "want a strong effort to improve the environment in Statsbygg, and it is desirable to have high ambitions for this effort." Contrary to most organisational efforts, which are often meant to improve the organisation's ability to achieve established goals, an effort to improve the environment also involves generating acceptance for a new dimension, a new set of goals and values that will constantly be under development and that can often conflict with those that are already established. Moreover, the environment has been relegated to testimonial speeches and objects clauses for so long that for many people it has become an empty word that is given very low priority in practice. Overcoming this apathy will be a challenge in Statsbygg as well.

The "Green State" project should act as a springboard for a systematic, long-term effort in Statsbygg to improve the environment. We now have a need for strong support from the top management, an integration of environmental ambitions into administrative documents and organisational processes, plus a visible environmental manager who shall coordinate the work and give it status. The goal is to integrate the eco-management and audit scheme into Statsbygg's ordinary control systems. The aim is a systematic improvement, follow-up and reporting of Statsbygg's results by means of specific performance indicators in the coming years. A task force has prepared a report with recommendations for the "Organisation of Statsbygg's efforts to improve the environment". This task force recommended establishing a new unit for the environment and a separate position as environmental manager to head this unit, and they mapped out a strategy for how we can achieve this objective.

This proposal is currently under consideration by Statsbygg's top management.

Guidelines for Sustainable Olympic Villages in Torino 2006

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The XX Olympic Winter Games in February 2006 will be held in Torino, which is located in northwest Italy, is the is the capital of the Piedmont Region and has around 900.000 inhabitants.
The importance of the environment in the Olympic Movement is stated in the Agenda 21 "Sport for sustainable development" of the International Olympic Committee: the environment is considered the third pillar of Olympism, alongside sport and culture. Following this address the Organising Committee (Toroc) has adopted the Strategic Environmental Assessment (SEA), a tool aimed to assess the environmental impact and economic compatibility of a work before the realisation with the intention to preserve the ecological value of the territory.
In this reference framework in January 2002 the "Guidelines for the Sustainability in Design, Construction and Operation of the Olympic and Multimedia Villages" have been delivered. This document has been developed by Environment Park, a science and technology park specialising in environmental technologies set in Torino, with the collaboration of the Polytechnic of Torino.

The "Guidelines for the Sustainability in Design, Construction and Operation of the Olympic and Multimedia Villages" are both a collection of green building design strategies and a list of the best technologies to put them into practice. The document contains the green performance requirements that all the residential, service and office buildings must meet and also an accurate information about:

- the indicators useful to check the sustainability of the construction during the whole building process;
- the tools to make these control indicators practical and efficient.

The many issues that the designer, the builder and the manager have to face up are organised in "Requirement Classes" and are illustrated in a concise way through 71 codified cards.
The "Requirement Classes" are:

- utilisation of climatic resources;
- environmental quality of exterior spaces;
- integration with environmental context;
- resource consumption;
- environmental loadings;
- quality of indoor environment;
- quality of service.

Inside the "Requirement Classes" the cards are classified and codified in relation to the "Sub Requirement Classes" and to the single requirements, as showed in Tables 1 and 2.

Each card, that is preceded by a short introduction illustrating the issue, is referred to a specific requirement.
In the card is specified:

- objective
  It represents the target that has to be achieved to characterise the construction in a sustainable way;

- qualitative requirement
  The qualitative requirement concerns the design chooses. It can't be verified by means of quantitative parameters. In the design stage its fulfilment is verified trough the analysis of the design chooses. The elements finalised to meet the objective have to be identified in the building's design;

- quantitative requirement
  The quantitative requirement concerns the design chooses. It can be verified by means of quantitative parameters. Its fulfilment is verified acquiring the results of the quantitative assessments performed by the designer;

- reference strategies and technologies
  The Reference Strategies and Technologies are the ones identified by the principal as the more suitable to fulfil the objective;

- control indicators
  The control tool is a parameter that has to be used by a third party (not the principal, neither the designer, builder or manager) to verify the fulfilment of the quantitative and qualitative requirements and to check the conformity of the building with the prescriptions. The indicator can be of different kind depending on the stage considered (design, construction or operation) and on the object of the assessment (qualitative requirement, quantitative requirement, conformity with the prescription). For instance the indicator may concern: the presence or absence of design elements, the use of a specific design solutions, the fulfilment of a standard, the result of a measurement (on field or in laboratory), the availability of technical support documents, the monitoring of a parameter;

- control tools
  Depending on the kind of the control indicator considered, the control tool may be constituted by technical documents (graphical supports, technical reports, numerical simulations, certifications of materials, results of measurements performed on field or in laboratory) that the designer, the builder and the manager provide at a third independent party. In this way it is possible to verify the fulfilment of the qualitative or quantitative requirements and to check the conformity with the prescriptions of the principal;

- essential norms and regulations
  This is a list of the mandatory norms and regulations and of the ones considered part of the good practices;

- correlated requirement classes, sub-requirement classes, requirements

These are the Requirement Classes, Sub-requirement classes and requirements correlated, from the design point of view, with the ones considered in the card;

- bibliography
  It's a list of the useful reference documents to study in depth the considered issue;

- reference norms
  These are the national and international norms with a not mandatory character that can be used both to study in depth the issue and to improve the efficiency of the design phase.

An example of requirement card is showed in box 2.

Considering that the Olympic and Multimedia Villages include buildings with different uses, on each card has been reported a code with the indication of the kind of construction to which the requirement has to be applied:

1. R = Residence Buildings;
2. U = Office Buildings;
3. S = Service Buildings.

The Guidelines present three appendices to support the designer's activity:

1. Environmental assessment tools
   This is an overview of the most important systems available to evaluate the quality level of a building from an environmental point of view. These systems can be classified as:
   a. rating and labelling systems, that allow to evaluate the performance of the building considering all the main green issues and to synthesize it in a vote;
   b. eco-tools, that are based on assessment procedures tied to the LCA methodologies.

   In the first appendix different assessment systems and tools have been described trough a card. An example of the application of the LCA methodology to the design of a building it is also reported.

2. Laws and regulations for sustainable building
   The second appendix contains the text of the mandatory laws and regulations concerning sustainable building that have been reported in the requirements cards.

3. Examples of eco-compatible installations (case studies)
   In the third appendix some case studies of eco-compatible settlements in Europe, Canada, USA and Australia are illustrated.

Table 1 – Requirements

Requirement Class	Sub-requirement Class	Requirement	CODE
Utilization of climatic resources	Natural heating	Passive solar systems	URC-Ris-1
	Natural cooling	Direct ground contact	URC-Rfn-2
		Night mass effect	URC-Rfn-3
	Natural ventilation	Ventilation generated by wind	URC-Vn-4
		Ventilation generated by stake effect	URC-Vn-5
Environmental quality of exterior spaces	Aspects of thermodynamic fluids	Control of surface temperatures	QAE-Tf-6
		Airflow control	QAE-Tf-7
	Noise pollution	Protection from noise generated out of the area.	QAE-Iac-8
		Protection from noise generated in the area.	QAE-Iac-9
	Air pollution	Protection from polluting sources present out of the area.	QAE-Iar-10
		Protection from polluting sources present in the site.	QAE-Iar-11
	Electromagnetic pollution	Low frequency electric and magnetic fields	QAE-Emf-12
		High frequency electromagnetic fields	QAE-Emf-13
	Aspects of perception and communication	Multi-sensorial perception	QAE-Pc-14
Integration with environmental context	Integration with the landscape	Safeguarding ecological systems	INC-Ip-15
		Environmental characters of the region	INC-Ip-16
	Integration with physical aspects of the culture	Salvaging/recovery with traditional local construction	INC-Cm-17
Resource consumption	Construction materials	Embodied energy	CCR-Ene-18
		Transport energy	CCR-Tras-19
	Potable water	Minimisation of potable water use	CCR-Acq-20
	Heating	Thermal insulation	CCT-Ris-21
		Efficiency of the heating system	CCT-Ris-22
		Use of renewable energy	CCT-Ris-23
	Mechanical ventilation	Efficiency of the ventilation installation	CCT-Vm-24
	Cooling	Control of the solar thermal radiation	CCT-Rfp-25
		Control of the thermal mass	CCT-Rfp-26
		Ventilation through buried ducts	CCT-Rfp-27
		Efficiency of the cooling system	CCT-Con-28
	Domestic hot water production	Use of renewable energies	CCT-Acs-29
		Efficiency of the heat water production system	CCT-Acs-30
	Production of electricity	Photovoltaic systems	CCE-Fv-31
		Cogeneration systems	CCE-Cog-32

Table 2 – Requirements

Requirement Class	Sub-requirement Class	Requirement	CODE
Environmental loadings	Pollutants emitted to atmosphere	Control of the emissions from the heating systems	RCA-Ea-33
	Effluents	Effluents management	RCA-Efl-34
	Noise or sound emissions	Noise control from technical systems	RCA-Ba-35
	Solid wastes resulting from the demolition phase	Recycling potential of materials	RCA-Ric-36
		Possibility to separate the building components	RCA-Sep-37
	Solid waste resulting from the construction process	Selective demolition	RCA-Ds-38
		Inert materials	RCA-Ine-39
	Control of the urban solid waste stream	Reduction of the urban solid waste to dump.	RCA-Rsu-40
	Construction materials	Environmental effects of the technical elements.	RCA-Efa-41
Quality of Indoor Environment	Visual environment	Daylighting	QAI-In-42
		Visual access to the exterior	QAI-Ve-43
		Access to direct sunlight	QAI-Os-44
		Lighting uniformity	QAI-Ui-45
		Visual Privacy	QAI-Pr-46
		Possibility to darken the rooms	QAI-Ob-47
		Electric lighting	QAI-Ia-48
	Acoustic environment	Noise attenuation through the building envelope	QAI-If-49
		Noise attenuation between occupancies	QAI-Ip-50
		Trampling noise attenuation	QAI-Fc-51
		Transmission of continuous building equipment noise	QAI-Rc-52
		Transmission of not continuous building equipment noise	QAI-Rd-53
	Thermal environment	Air temperature in wintertime	QAI-Ct-54
		Indoor surfaces temperature in wintertime	QAI-Ct-55
		Overheating in summertime	QAI-Ct-56
	Air quality	Ventilation	QAI-Ae-57
		Air exhaust	QAI-Ea-58
		Relative humidity	QAI-Ur-59
		VOC emissions	QAI-Ev-60
		Radon control	QAI-Rn-61
		Pollutants propagation	QAI-Di-62
	Electromagnetic pollution	Low frequency electric and magnetic fields	QAI-Emf-63
		High frequency EMF fields	QAI-Emf-64
Quality of Service	Flexibility & adaptability	Ease of adapting technical building systems	QS-Fa-65
		Spaces flexibility	QS-Fa-66
	Controllabilità of systems	Capability of control over heating and ventilation systems	QS-Cr-67
	Maintenance	Solid waste reduction from maintenance operations	QS-Ma-68
		Building envelope protection	QS-Ma-69
		Access to technical systems	QS-Ma-70
	Monitorino of performance	Consumptions control	QS-Mo-71

Educating Built Environment Professionals for Sustainability

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ABSTRACT

This paper outlines the contents of a special course on sustainable construction which is aimed at civil engineers, architects and other professionals who are involved in creating the built environment in Mexico. The aim of the course is to promote the incorporation of sustainability principles into the construction sector. As a way to assure its success some agencies from the private sector have been brought on board to support the course. Moreover, experts from national and international institutions will lecture key subjects.

It is important to create links between the private construction sector and the University to promote sustainable development within the construction industry.

1. INTRODUCTION

In many developing countries the relationship between protecting the natural environment and economic development is overlooked. These countries often rely heavily on the exploitation of their natural resources for income therefore environmental degradation could be a secondary issue.

The concept of sustainable development means limiting the exploitation of natural resources, therefore sustainability must not mean preserving current stocks of resources within developing countries, but searching for efficient ways to use resources and also taking into account the integrity of the environment and social stability for both present and future generations.

The construction industry is one of the largest industries in the developing world not only in terms of investment but in terms of its impact on the environment. The construction industry has far reaching impacts and can lead to:

- The loss of agricultural land
- Soil erosion
- Forest degradation
- Deforestation
- Water pollution
- Loss of biodiversity
- Loss of non-renewable resources such as minerals.

To tackle these problems, the concept of sustainability has become increasingly important to people living within the built environment and they have realized that environmental and social degradation can have an adverse affect on their quality of life.

Therefore due to growing awareness and international legal requirements the issue of the environment is now at the forefront of national agendas. Professionals in the built environment, such as engineers and architects, must become more attuned in practice to environmental and sustainability principles and techniques.

That means that construction professionals have to take into account issues that they have not bothered with so far. As a consequence, universities and educators must reconsider the curricula content for degree programs. It is recognized that this task is time consuming and difficult for those involved. Therefore a group of university lecturers, researchers, and authorities at the *Higher School of Engineering and Architecture* (ESIA) Mexico, concerned with environmental and social degradation in the Mexican Republic, are working on the implementation of a proposal for a specialized course on sustainability. This course will focus on professionals working in the built environment, including final year bachelor students.

We believe that this course can aim to promote and encourage sustainable development and the use of sustainability principles in the construction sector. A key issue which must be addressed would be the genuine cooperation between the private sector (with whom we have already contacted) and the academic authorities, in addition we aim to work in cooperation with international institutions who support Agenda 21 principles (chapter 37).

The proposed course outline is as follows:

2. OBJECTIVE

Civil engineers and architects already understand the economic and financial implications of their decisions on construction, as well as some basic environmental impacts and elementary social cost-benefit accounting. Additional information required to promote sustainability in the construction industry is:

- Introduce a design that takes in consideration environmental impacts,
- Promote resource conservation, water and energy conservation features, waste minimization on construction process and on the end of life span,
- Reduce operation and maintenance costs,
- Among others social, ecological and economic issues that slow down and stop the degradation process on the built environment.

More specifically, the course aims to:

* Offer a conceptual, methodological and pragmatic framework to initiate or to up-date professionals working in the built environment so they can focus on the design, construction and operation of the built environment whilst taking into account environmental issues.

* Supply Human resources concerning with the environment issues to productive, public and social sectors. ??

3. JUSTIFICATION

In Mexican development plans local authorities have begun to partially address some environmental and sustainability issues, for example the need to complete an Environment Impact Assessment (E.I.A.) (Mexican Government, 2001). However policies that are aimed at addressing environmental and sustainability issues haven't as yet been implemented outside of protected areas. (CONABIO, 2002).

Therefore there is a real need for qualified professionals to address emerging environmental and sustainability issues on a national basis. The growing market within Mexico must be open

to the potential of sustainable development and this must be supported through the provision of coherent academic courses for professionals and final year students. To reinforce this hypothesis, we include a declaration of the current Republic President:

"*We will make Mexico´s environment, its water and forest, a national-security issue, we will turn around the concept of development to include the environment as a factor in economic and social decisions, not as a separate sector, but as an essential element in creating sustainable economic and social progress".*

The Law of Ecological Equilibrium and Protection of the Environment stated (article 39) that *"... the higher education institutions and the scientific and technological institutions must develop programs for the specialist formation on the environment field...".*

Accordingly, the Graduate area of ESIA (Faculty of National Polytechnic Institute) is available to organize and offer the specialized course: **Education of Built Environment; Professionals for Sustainability**. In order to assure the attendance we are negotiating with the Private Sector Institute for Sustainable Development (CESPEDES, 2002) and with the Mexican Chamber of Construction Industry (CMIC, 2002), they are quite interested in the course.

4. PROFILE OF ENTRANTS

Aspiring students must possess a primary degree in one of the following professions:

1. *civil engineering,*
2. *architecture,*
3. *construction or related areas.*

5. PROPOSED SUBJECTS FOR THE COURSE CURRICULUM:

- Introduction to Environmental Sciences
- Introduction to Research Methods
- Urban Economy
- Sustainability and Sustainable Development
- The Urbanization Process and the Environment
- Environmental Management Systems
- Water, Soil and Air Pollution
- Sustainable land use
- Sustainable management of Urban Facilities
- Support methods for Sustainability
- Building Environment Performance Assessment Methods
- Environmental Laws and Enforcement
- Seminar on Society and the Built Environment
- Workshops: Local Agenda 21, Building Quasi-sustainable assessment Performance

Sustainability can be addressed at two different levels, that of the building project and that of the community. Thus, at least two research lines will be available for students to write their final dissertation, for example projects on environmental assessment of buildings and applying local Agenda 21 principles.

6. ANOTHER ACTIVITIES TO BE CARRIED OUT BY THE STUDENTS

* Besides the regular classes, students must complete a minimum of 80% of their final dissertation (minimum: 7000 words) the format will be stipulated by the course co-ordinator.

* At least four field visits on environmental projects and construction will take place.

7. ACADEMIC CALENDAR:
The course will run for an academic year.
The class timetable will predominantly be in the afternoon in order to allow flexible working arrangements.

8. ACADEMIC AWARD:
Students that fulfill the academic and administrative requirements will be awarded a *Graduate Diploma in Sustainable Construction of the Built Environment*

9. PROPOSED LECTURERS ON THE COURSE:
Dr. Joseph Antequera, Polytechnic University of Caytalonia, Spain.
Dr. Ruben Cantu, ESIA , Mexico
Dr. Peter Erkelens, Eindhoven University, The Netherlands.
Mr. Nils Larson, CETC, Natural Resources Canada (to confirm)
Dr.Victor M. Lopez-Lopez, ESIA , Mexico
Dr. Gabriel Quadri, Director of CESPEDES, Mexico
MS. Silvia de Schiller, University of Buenos Aires, Argentine.
Mr. Tom Woolley, Queens University, Belfast, UK.

10. INSTITUTIONAL LINKAGES
For the purpose of the course we are in touch with and have support from Universities and Institutions that represent the above lecturers quoted, among other local and national agencies and authorities.

11. CONCLUSION
It is fundamental to the success of the course that the private sector is involved from the inception phase only then can sustainable practices be incorporated into the industry at all levels. The proposed course *Educating Built Environment Professionals for Sustainability* aims at promoting sustainability principles and techniques within the construction industry to reduce the impact of the industry on the natural and built environment.

The involvement of members of the construction industry (CESPEDES and Mexican Chamber of Construction Industry) is an encouraging start for the promotion of sustainability in a developing Country known for conservative building practices.

If the relationship between the private sector and the academic sector is a success it could pave the way for the incorporation of sustainability principles into other degree programs which are part of the ESIA. Finally, if you have any suggestions, comments or recommendations regarding this proposal please do not hesitate to contact the above.

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INTRODUCTION

Despite the introduction in April 2002 (DTLR 2001) of revised Building Regulations (Part L, Conservation of Fuel and Power) within the UK, they remain well below those in Sweden and parts of North America. It has been argued (Lowe and Bell 1998) that in order to make significant reductions in CO_2 emissions a long term strategy of building regulation improvement needs to be established. It is recognised however that at each step the construction industry and government will need to be convinced that any proposed standard is feasible in practical and commercial terms as well as minimising technical risk. Although many of the technical design and performance issues are well understood by experts and technical feasibility has been demonstrated in a number of schemes in the UK (Olivier & Willougby,1996; DETR,1998) none have addressed the questions that arise in seeking to achieve such standards in mainstream house construction.

There is no tradition, in the UK of field trials designed to comprehensively evaluate a given standard in advance of implementation and it is arguable that the lack of such pilot projects has led to an approach based on incremental rather than radical change. Given the likely scale of CO_2 reduction requirements over the next 50 years, an incremental approach is untenable. The project reported here seeks to carry out such a field trial based on a social housing development of some 20 dwellings in York which is designed to meet a standard equivalent to the 1995 Swedish regulations. Details of the project, its objectives, methodology and the proposed standard, are discussed in Lowe et. al. (2000)[1]. The field trial was initiated in 1999 and it is expected that the findings of this and a companion project[2] will inform a review of UK building regulation post 2008.

Land acquisition delays have meant that dwelling construction is unlikely to begin until late in 2002 at the earliest and final details, mainly from upstream suppliers, cannot be finalised until the uncertainties are resolved[3]. However, detailed design is sufficiently well advanced for some understanding to be gained of the process to date. Based on participant observation (Whyte 1991) and other qualitative data, this paper seeks to make an assessment of design

[1] The standard was initially based on proposals by Lowe and Bell (1998) for regulation in 2005. Since the start of the project in 1999 minor modifications have been made to the proposed standard and the latest version is referenced in this paper (Lowe and Bell 2001). The likely time scale for regulation review is now 2008.
[2] A similar field trial involving a commercial housing development of over 600 masonry dwellings (Brookside Farm) is due to begin in the autumn of 2002.
[3] At the time of writing the delays have placed doubt on the continuation on the research project because of funding difficulties. There is, however, reasonable certainty that the scheme itself will be constructed.

decisions, and the overall impact of the energy and environmental performance standard itself. The data used consists of formal and informal notes of design and progress meetings and open-ended interviews with team members during the design process.

THE PROJECT TEAM AND OVERVIEW OF THE PROCESS.

The team was assembled over a 12 to 18 month period beginning in the spring of 1998. In the initial phase the team consisted of the Client, Architect and Quantity Surveyor who worked on the initial design concept (figure 1) and the approach to procurement. It was during this phase that the performance standard was introduced in outline form (Lowe and Bell 1998) and the research established. The client's strategy was based not only on the proposed standard but also on the adoption of a partnering approach, an approach in which the client, designers and constructors work together on the project (Egan 1998). The decision to adopt this approach was partly a result of incentives offered by the Housing Corporation[4] and partly based on the view that it would facilitate the process of technical innovation.

Following receipt of funding approval in February 1999, the planning supervisor (a health and safety role), the partnering contractor and key suppliers were added. All team members came to the project with a considerable commitment to the partnering and environmental objectives but only the Architect, Quantity Surveyor, Planning Supervisor, and H&V system supplier had any track record in energy conscious design. Normal lines of professional responsibility were maintained but all team members were expected to contribute with all major issues open to scrutiny and criticism. This enabled a full discussion of proposals and the forging of a strong team ethos, which facilitated discussion in potentially difficult areas.

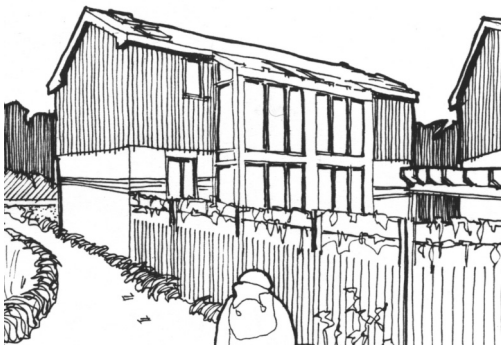

Figure 1 Initial solution

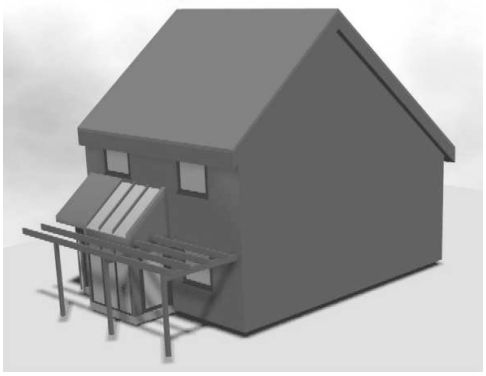

Figure 2 Final solution[5]

The initial design concept formed the starting point for the selection of the contractor, who was required to present detailed design proposals that complied with the enhanced standard. In order to provide a focus for the team, a prototype approved document (Lowe and Bell 2001) was presented in November 1999. The process was also informed by a series of one day seminars (facilitated by the research team and external consultants) on energy efficient design. The research team played an active part in all design meetings, providing detailed design advice and feedback on proposals so as to ensure adherence to the proposed standard.

Figure 2 shows the final design and Table 1 presents an outline of construction, as submitted in March 2001 for approval under the then current Building Regulations (DoE 1994)[6]. The

[4] The principal funder of social housing development in the UK.
[5] Architect's drawing & model by P. Bixby, Constructive individuals, York.
[6] A "mock" building control exercise using the prototype standard is planned prior to the work commencing.

solution retains timber frame construction but shows some important modifications to the original concept. The principal changes included the reduction of the sun space to a single storey, and modifications to the plan and roof (increased pitch and cold roof to warm roof construction). The decisions on modifications were interrelated and to a large extent driven by changes to the roof. This is discussed in the roof design section below.

Table 1 Outline of construction

Element	Construction
sub-structure	Pile and beam foundations, cavity block/brick work to ground level.
Floors	Beam and block suspended ground floor, 75mm EPS insulation under 75mm screed & edge insulation. Timber suspended first floor; composite floor joists.
External walls	Small panel platform timber frame; integral air/vapour barrier, 44x 89 studs, cellulose fibre insulation between, 44mm extruded polystyrene ext. insulation and softwood/cedar external finish: 25mm service space; plasterboard finish internally.
Roof	Timber I-beam warm roof; cellulose fibre insulation, air/vapour barrier linked to wall air barrier, reclaimed slate covering and plasterboard internal finish.
Windows & doors	Softwood windows with 20mm low emissivity double glazing units. Steel polyurethane core doors in hardwood frames.
Heating & ventilation	Combination condensing gas boiler; hydronic space heating system and instantaneous domestic hot water: MVHR or extract only ventilation depending on dwelling.

ACHIEVING THE STANDARD – KEY DESIGN ISSUES

Wall design

The key issue in the design of the timber frame was that of thermal bridging through timber studs and at junction details. Initial proposals took a traditional approach involving the use of full thickness studs (195mm) with mineral fibre insulation between and junction details that made little effort to reduce thermal bridging. Although U value calculations suggested that the required values would be achieved, they failed to take into account the significant level of thermal bridging that was present[7]. Advice from the research team early in the process enabled the full impact of bridging to be understood and the wall construction redesigned (see table 1). The principle was established at a single design meeting and applied to junction and opening details as well as panels. The ease with which the issue was resolved was remarkable given current UK practice. Thermal bridging simulations[8] on typical junction and opening details demonstrated that this approach was reasonably successful with additional heat loss amounting to about 8% of the total fabric heat loss and a wall U value (based on the sharing of bridging effects at junctions) of around 0.22W/m^{2}K compared with an elemental standard of 0.25W/m^{2}K. The average envelope U value was some 6% to 11% below the target of 0.35 W/m^{2}K depending on assumptions made about window U values and (crucially) areas. It is expected that thermal bridging will be reduced even further when details are finalised.

Airtightness

Considerable attention was given to this issue during design meetings and was widely acknowledged in the team member interviews as an important area of learning. Concern for airtightness was instrumental in the adoption of a design approach that sought to avoid the need to penetrate air barriers. Service penetrations in external walls were minimised by the provision of a 25mm service space behind internal finishes and the design of junction details sought to maintain air barrier continuity. An initial qualitative analysis of design drawings

[7] High levels of thermal bridging are common in UK timber frame design. In one study (Bell and Overend 2001), timber fractions of between 30% and 40% were observed.

[8] Using THERM (2.1a) a 2D finite element thermal simulation programme developed by the Windows and Daylighting Group, Lawrence Berkeley National Laboratory, University of California USA.

suggests that the required airtightness standard could be achieved but realised performance depends on the quality of construction as well as design and will not be known until the completed dwellings are pressure tested.

Window design
For cost reasons the design team wished to achieve the required elemental whole window U value of 1.3W/m^{2}K using double glazed units in timber frames. Work by the research team (Roberts & Lowe 2002) on the effectiveness of this approach suggests that, in most window configurations, this will be very difficult to achieve. It is, however, likely that with careful window specification (very low E coatings, inert gas fill and warm edge construction) a value of 1.5W/m^{2}K is achievable. If this were the case, the proposed dwelling designs would satisfy the prototype standard, using the Target U Value Method[9].

Roof design
The change in roof form and construction (from a cold trussed rafter roof to a warm roof using timber I-beams) was the result of concerns about thermal bridging and airtightness, a desire to locate the mechanical ventilation equipment within the heated space and a re-evaluation by the client of the potential offered for additional habitable space within the roof. This provides an interesting example of the interplay (and, in this case, alliance) between a wide range of factors and the capacity of partnering to achieve the necessary integration. The change was also facilitated by a delay in the programme, brought about by land acquisition problems. It is unlikely that any one design issue would have justified the change or that without a delay in the programme the time would have been available to effect the changes. However, the increased cost of the changes resulted in a need to identify cost savings elsewhere. The modifications described in the previous section were a response to this but were also supported by other relevant design considerations. The reduced sun space addressed overheating concerns and the modified plan form was influenced by a desire to simplify the design of the thermal envelope and reduce the potential for thermal bridging.

Heating and ventilation design
Initial suggestions that the proposed standard, in the UK climate would enable space heating to be supplied through a heat recovery ventilation system were not supported by detailed design calculations and a more conventional approach was adopted (table 1). The project team took the view that the airtightness standard necessitated the installation of a mechanical ventilation system and two strategies are being compared (table 1). There is, in the UK, considerable scepticism about, and resistance to high levels of airtightness and the application of mechanical ventilation systems in housing. Much of this scepticism relates to internal air quality. In order to address some of these reservations (and reactions to a reduced heating system), occupation monitoring will include user perceptions of the heating & ventilation systems and air quality as well as technical performance.

REFLECTIONS ON THE PROCESS AND INFLUENCE OF THE RESEARCH TEAM

Perhaps the single most important ingredient in the project is the considerable commitment to the objectives shown by all members of the team, most of whom have incurred costs that

[9] The prototype standard adopts UK regulatory practice and defines a threshold for each element (Elemental Method) and alternative methods based on a target envelope average (Target U Value Method) or CO_2 emission rate (Carbon Rating Method). Limiting U values are specified to control trade-off. In the case of windows the elemental value of 1.3 W/m^{2}K may rise to 1.5 W/m^{2}K as long as the envelope average or CO_2 targets are not exceeded (Lowe and Bell 2001). This is satisfied in the field trial case by virtue of a reduced window to floor area ratio (20% compared with 25% in the target U value formula).

remain at risk if current acquisition delays continue. As one would expect, the standard provided a very clear focus for the design work and was used on numerous occasions as a way of assessing solutions and ideas. In this sense, the prototype operated as a quasi regulation and was accepted as such by the team. Almost all team members cited the importance of the partnering mechanism in facilitating an open approach to design decision making. This enabled a broader range of knowledge and expertise to be applied to design decisions than is usually the case and was of particular importance in providing support for decisions that had a direct bearing on energy and environmental performance.

The design that emerged was an interesting mixture of modified conventional construction for the walls and floors and a more adventurous roof construction. The roof design process demonstrated the difficulties of making a transition from traditional well-understood solutions to alternative approaches. In the initial design phase the I-beam solution was rejected almost immediately on grounds of cost and, possibly, unfamiliarity. The focus of attention was on making the trussed rafter solution work, a process that promised to produce some complex details as attempts were made to resolve the problems of airtightness, structural thermal bridging at eaves, and housing the ventilation equipment. The technical simplicity of the I-beam solution was widely acknowledged but this was not enough to overcome the cost arguments. As indicated above, achieving change required a strong alliance of different needs coupled with a delay in the programme. The lack of a well developed and high volume UK supply stream is largely responsible for the high cost involved and the twin problems of cost and lack of experience create real and interrelated barriers leading to a vicious circle of inhibition. The wall construction is a similar case in that the external insulation layer compromises, to some extent, the client's desire to minimise the environmental impact of the materials used. The obvious solution, using I-beam walls with cellulose fibre was, however, rejected on cost grounds and a way was found to make the traditional construction work.

As one would expect, the research team played a significant role in providing support. At one level they acted as the guardian of the performance standard and were able to provide a constant reminder of the level of performance required. To some extent this reflects the role played by the existence of a formal regulation and regulatory enforcement mechanism. On another level, the team facilitated training in the key principles of energy efficient design and provided a technical support service for the analysis of construction details. Support included the calculation of Ψ values for linear thermal bridges, their incorporation into heat loss calculations[10] and the qualitative assessment of other performance aspects such as airtightness. If the performance standard were adopted by regulation it would be necessary to ensure that training programmes, technical literature and specific design tools were provided to replace the support given in this pilot project. Simplified methods for estimating Ψ values, perhaps based on catalogues or typical constructions for common details, would be crucial to success. The explicit training on this project was, however, not extensive. Key principles were absorbed very quickly and applied in design. In many cases it was a matter of tapping into existing knowledge and pointing out its significance. For example, thermal bridging and airtightness were understood as concepts but their significance and prevalence in existing practice were not appreciated. Clear illustrations of significance were enough to convince team members that these aspects were to be taken seriously and incorporated into all aspects of design decision making. For one team member this was almost a "eureka" experience:

[10] Many aspects of the energy performance standard (including impacts of ventilation strategy and air leakage, thermal bridging and window energy rating) were incorporated into a modified Standard Assessment Procedure spreadsheet.

"*One particularly outstanding piece of knowledge was how leaky buildings are. I thought that air-tightness day was a revelation……..I've become so aware of cold bridging. I was impressed by the degree to which it has been addressed on this scheme - the amount of thermal bridges that I wasn't aware of!"(design team interview)*

Other aspects of research team influence and support were more subtle and difficult to define. Since the research team played a full part in the design process their tacit understanding and knowledge of the issues and possible solutions was integrated with the expertise of other members of the team. The opportunities this provided for a two way transfer of knowledge were considerable. Many of the team members interviewed indicated that they had learned a great deal from participation in design workshops and valued the range of views expressed on all aspects of detailed design. This deeper learning would be hard to replicate in traditional training programmes and is much more likely to be developed through informal osmotic processes as the industry gains in experience. It is suggested that a strong case could be made for developing experience, prior to regulatory change, through a more extensive programme of pilot projects such as the one reported here.

CONCLUDING COMMENT

The principal message emerging from the work reported here is that higher energy and environmental performance standards need hold few fears for the UK house building industry. Even though the prototype performance standard is a significant step forward the project team did not find the design problems it presented difficult to overcome. However key questions relating to the achievement of the required standard in practice and occupier perceptions cannot be answered until the scheme is constructed and occupied.

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In search of Environmental Impacts with Beneficial Effects for the Client

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1. ENGEL SERVICES

The services of the Engel Group cover the entire life cycle of the property. Clients come from both the public and the private sector in Finland.

Internal co-operation between construction management and real estate services at Engel has been strengthened on the practical level and in terms of product development. The synergy benefits thus obtained will be channelled into solutions that are beneficial to the client in both the short and the long-term. New types of service package combine consultancy services, maintenance, cleaning, security services etc, according to the client´s needs. Engel is also ready to share financial responsibility with the client for maintaining predetermined conditions in the premises.

Engel controls quality through EFQM and environmental performance by applying the principles of ISO 14001. The basic approach to solid long-term values and environmental performance of the properties is that they support each other. Ethically the business is based on sustainable development, having ecological, economical, social and cultural dimensions, as presented in the present Finnish Land Use and Building Act.

2. NOT ONLY ADVERSE, BUT ALSO BENEFICIAL CHANGES

ISO 14001 defines environmental impact as ”any change to the environment, whether adverse or beneficial”. The most common way of interpreting the environmental performance of the buildings deviates from this definition. Check-lists based on avoiding adverse changes with negative impacts, predominate. Much attention is focused on environmental burdens that are the result of energy consumption while the buildings are in use.

Within the construction and property sector there are opportunities to gain benefits for the owner and the tenant that can also lead to beneficial changes to the environment or which have minor or even zero-level adverse impacts. These issues should be handled in a way that is in the interests of the main parties involved, the owner and the tenant.

Any client of a service company which aims to demonstrate better environmental performance with the idea of continual improvement, is eager to publish positive reports on its own surroundings, as well as the functional and technical features that affect its products or services or appear in them. This includes irrational subjective factors, which influence the image of the owner´s and tenant´s businesses, and also concerns the work of consultants and maintenance firms.

According to ISO 14001, the environmental aspect is ”the element of an organization´s activities or products or services that can interact with the environment”. The environment is

defined as ”the surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelation”. The latter part of the definition of environmental impact is important: ”any change to the environment, wholly or partially resulting from an organization´s activities or products or services”.

So, for an organization in the construction and property sector working according to the principles of ISO 14001, the field of targets for environmental management is immense. For a service company working for clients who are striving for environmental performance that meets ISO 14001, there is no other choice than to follow the same principles. They set the criteria for the end result and the operating procedures needed to achieve it.

3. EXPERIENCES ON ISSUES

New issues and new areas of focus have been found in projects run by Engel Construction Management Services, in addition to those whose main purpose is to lower adverse impacts. Some of the goals are non-numerical. The main tactic is to modify ”traditional” ways of carrying out ”traditional” solutions, by considering overall material and energy economy from the life cycle perspective. This also includes aspects of maintenance and the development potential of the property in the future.

Defining the quality of the internal conditions is one of the most important items for diccussion between owner and tenant, because of the need to determine energy consumption and costs. It should be handled when the lease is drawn up. Ways of sharing the running costs lead to more or less motivation towards energy economy.

In Engel services the figures for managing energy use and its environmental impacts are calculated according to the client´s needs. Money spent on energy matters. Even though global impacts are recognized, it often seems that what is ”physically” near is also clear and comprehensible to the client. Consequently, energy use is not normally seen as a main consideration in the overall approach and in the many subsidiary issues which affect the client´s business.

Efficiency is not simply a matter of economics, but is also an important ecological issue. It includes a study of land use, the building, separate premises, and individual rooms. More efficient layouts in office buildings can provide more working places using the same quantity of material at the construction stage, or even less, and lower energy consumption in the future. Actually, it is the efficiency per service unit, which shows the ecological efficiency of the whole building.

Multiple use, flexibility and ways of dividing the building into different premises offer good potential for the future. They are the result of good professional design. They cannot be set as numerical goals beforehand, neither can the results be shown numerically. These are strategic goals that hold enormous potential, but also risks. Their implementation depends on future trends and demand.

Moreover, targets for the extendability of the building necessitate precise goalsetting from the owner, starting from business strategy. What is invested now can be payed back in the future many times over.

Major property developments affect society by changing the local functional, economic and social structure. Moving to a better location for stake-holders serves the business and, at the

same time, diminishes the pollution caused by traffic. The interrelation between the owner´s and tenant´s benefits and the infrastructure is more than apparent.

4. EXPERIENCES ON PROCESSING

In order to arrive at more environmentally aware processes, the basic interests and responsibilities have to be defined and divided between the two main parties, the owner and the tenant. This should happen at the initial stage of a project. The owner has overall responsibility for the property, the tenant for the environmental impacts of its functions, but indirectly for the conditions it requires for its premises, as well.

Construction management procedures should contain a review of the existing site conditions, with details of the consumption of energy and water by the existing buildings. Environmental targets for the work of the consultants and the contractors have to be set. At the end of the preliminary stage, a report on the environmental features of the project is needed for decision-making and for detailed design of systems, and for recognizing environmental issues in the construction phase.

During the planning stage the consultants´ work has to be integrated and alternatives have to be drawn up and compared. The beneficial and adverse changes, leading to beneficial and adverse environmental impacts, can be compared with the owner´s other properties, tenant´s present premises, and/or parameters for the same building type.

Sun Shading As Energy And Environmental Efficiency Measure

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1. TARGET

This project aim to demonstrate the potential of solar shading devices to provide thermal- and daylight comfort and a low energy use. Solar shading can work as passive cooling, daylight device, passive solar heating and night insulation. In this project we want to use and show some of the potential of all these properties. Split into sub targets we want to show:

- Temperature control in summer and winter
- No need for local cooling):
  - reduced investments
  - no electric energy use for local cooling.
- Daylight comfort summer and winter
- Reduced electric energy for lighting
- Reduced heating energy

2. METHOD

A simple way to reach these targets is demonstrated in a case study of the technical solution in a real office. The case study is documented through measurements and calculations.

2.1 The Office

The office used was a south facing standard office in a building from 1969. It is located at SIEMENS in Oslo. The office was equipped with the suggested technical solution and control strategy. It had a standard PC and was modelled with a 100 W heater simulating a person in the room. The office is shown in Figure 3. The room has balanced ventilation and electric heating. It is central cooling of the supply air, but there is no local cooling. All the neighbouring rooms have a temperature around 22 ^{o}C.

Room thermal data

	Area m^2	U-value W/ m^2 ^{o}C	Solar factor	Light transmissiom
Window	3,6	2,7	0,76	0,82
Wall	3,5	0,2	----------	----------

Heat gain

	Heat W	Scedule
Light	100	8-16
PC	-	-
Persons	100	8-16

Ventilation

Air flow m3/h	Supply air temperature °C	Scedule
150	18	5-22

2.2 Technical Solution

To be able to control the light white adjustable blinds was selected.

Marit Smidsrød 28.5.02 16:16
Gelöscht:

To control surplus heat in the summer outside shading was installed. To use passive solar gain in winter while providing good daylight interior blinds was also installed. Both the interior and outside blinds were used as night insulation.

To be able to run the automatic control strategy the blinds were motor driven.

A programmable control unit was installed connected to the blinds, the light and the heater. The principle of the technical solution is shown in Figure 1 Principle of technical solution and monitoring equipment.

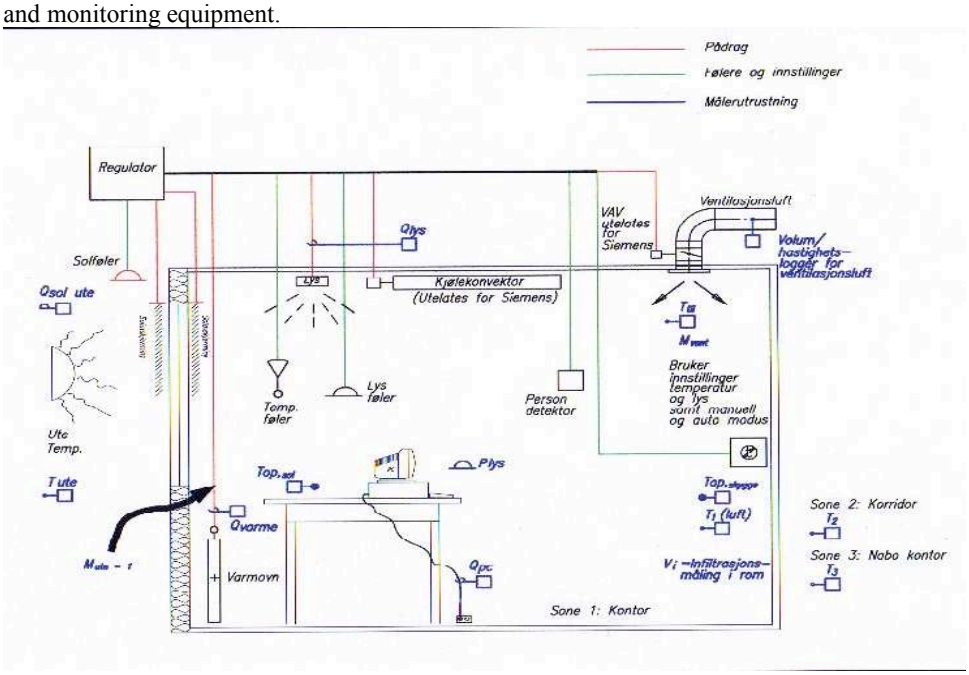

Figure 1 Principle of technical solution and monitoring equipment.

2.3 Control strategies

Different control strategies to fulfil the targets were described. The main difference between the strategies is the control parameters for switching between inside and outside shading and use of night insulation

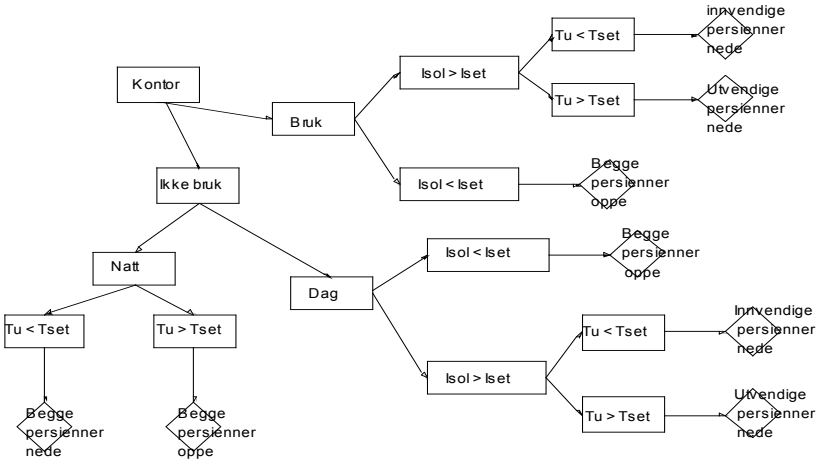

Figure 2 Control strategy with night insulation and passive solar gain introduced when ambient temperature is below Tset.

2.4 Measurements

Outdoor conditions thermal comfort parameters and energy use was measured for different solar control strategies during sunny days.



Figure 3 Office

The office was measured on sunny days with no shading device, inside and outside shading devices. The measurements were used to verify the thermal comfort of the solution and to validate the simulations.

2.5 Calculations

Simulations were made with the simulation program TRNSYS. To validate the room model thermal comfort was calculated for the room with no shading, and with inside and outside shading.

Finally the energy consumption was calculated for the room with a reference case and with different levels of the control strategies introduced.

3. THERMAL AND VISUAL COMFORT

Air temperature, operative temperature in the sun and the shade was measured for all the cases. The measurements presented in Figure 4, **Figure 5** and **Figure 6** showed that the operative temperature in the shade and the air temperature were below 25 °C for all the cases. All standard documentation by simulations or measurements of operative temperature is in the shade. This means that according to a standard documentation of thermal comfort all the solutions would have been considered as good. The operative temperature on the workplace (also called operative temperature in the sun) on the other hand shows large differences. Without shading the operative temperature is above 30 °C. This shows that solar shading is necessary to obtain an operative temperature below 25 °C.

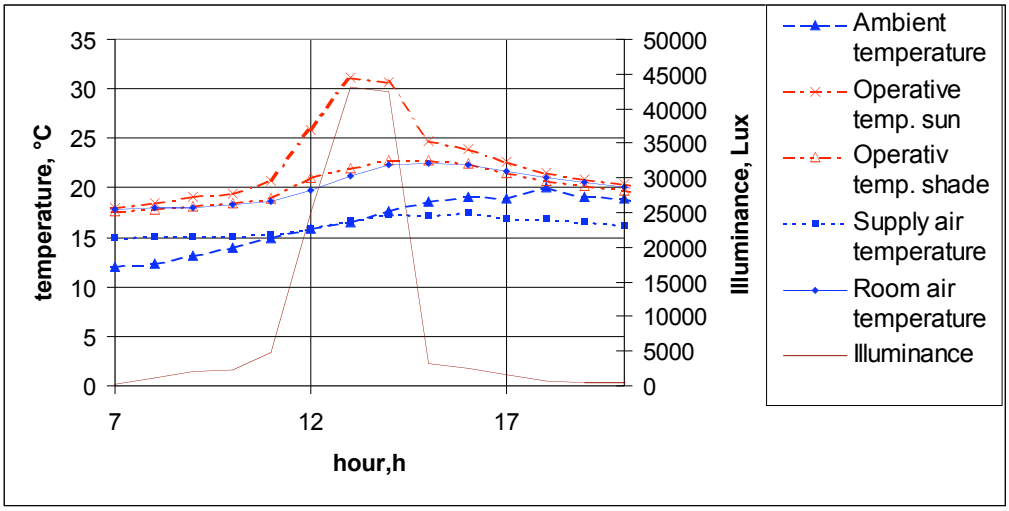

Figure 4 Air -, operative temperature in the shade and operative temperature in the sun with no solar shading. Date: 120800.

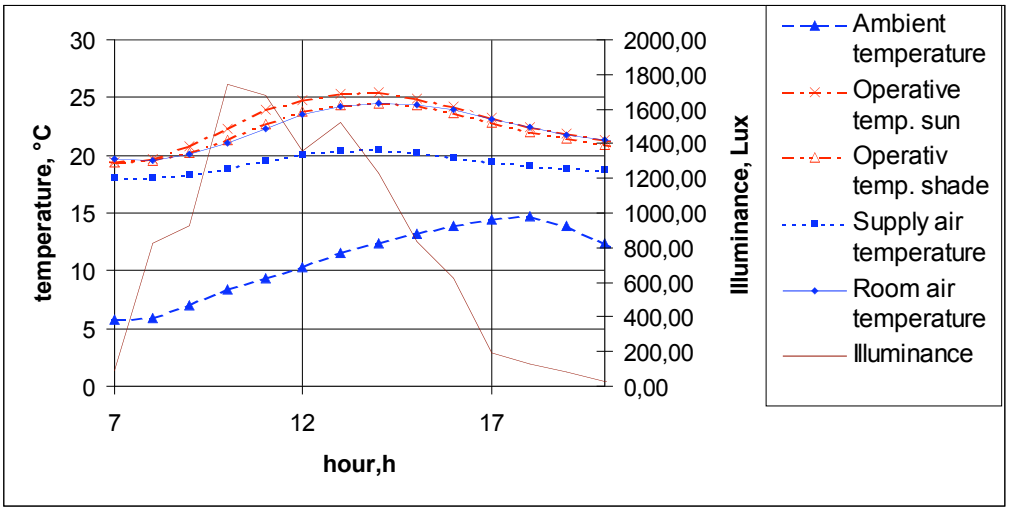

Figure 5 Air-, operative temperature in the shade and operative temperature in the sun with outside shading. Date: 120900

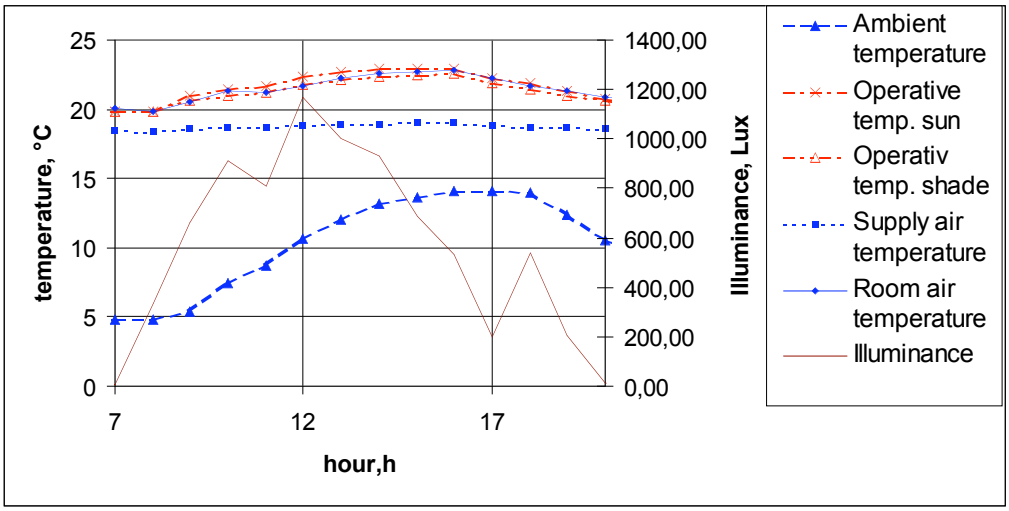

Figure 6 Air- , operative temperature in the shade and operative temperature in the sun with interior solar shading. Date: 260900

If we look at the data for light we also see that in periods the illuminance is above 40 000 lux without solar shading which is too much for computer work and is likely to cause glare. This means that solar shading is necessary to control the light. For the cases with outside and inside solar shading we see that the illuminance is above 600 lux all the working day and below 1700 lux for the interior shading and 1200 lux for the outside shading. This means that we have large potential to achieve light comfort with the solar shading.

Solar shading is necessary to ensure full thermal and visual comfort in office buildings.

4. ENERGY USE

The energy use was calculated for different control strategies by introducing new solutions step by step. The results are shown in Figure 7.

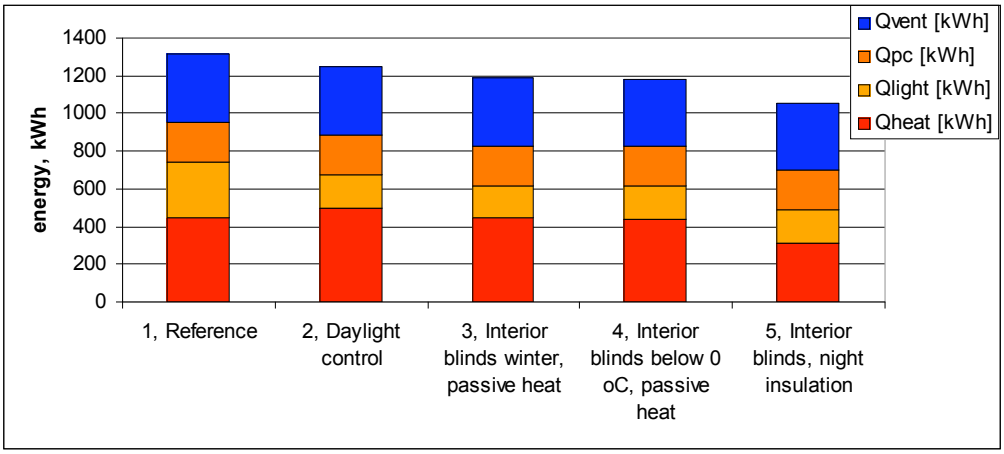

Figure 7 Energy consumption for different control strategies.

The reference (1) has standard outside shading and ordinary light. The energy consumption is 1310 kWh for the office. All the solutions have outdoor shading alone or in combination with interior shading. The first strategy (2) is to introduce daylight control. It reduces the energy consumption to about 1250 kWh. The heating energy use increase and the energy for light is reduced. The net reduction is 60 kWh electricity and increased energy flexibility. The next step is to use the outside shading only in the summer and the inside in the winter. This is calculated with a switch controlled by date (3) and by outdoor temperature (4). The result is the same, an energy consumption on 1190 kWh. This is 60 kWh saved heating by use of passive solar gain.

By introducing solar shading as night insulation (5) the final result is 1060 kWh which means a reduction on 20% or 26 kWh/ m^2. If refurbished this office would normally have local cooling. An introduction of local cooling would rise the energy consumption per office with 20-60 kWh/ m^2 in addition. This shows that the potential of the solar shading technology is huge for energy saving. Demonstration and full scale projects would be useful for documentation of the real benefit of the technology.

5. CONCLUTIONS

The project shows that the solar shading can provide good thermal and visual comfort and low energy use. The project showed that it was difficult to get the correct and necessary data on the window and solar shading. If we shall base much of the environmental solution on this technology it is necessary that the suppliers provide correct data on solar transmission, light transmission and U-value for the solar shading and window as an assembly.

This project is funded by the National Research council, The Norwegian Solar Shading Association, SIEMENS, Vental and Erichsen & Horgen.

Linking the GBTool to the Design and Decision-making Process

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The Green Building Tool (GBTool) currently provides a detailed assessment of buildings but is only loosely connected to the decision-making process. This results in most of the building industry considering the GBTool to be largely irrelevant to their performance. This paper explores how to connect the GBTool to the decision making process by analyzing the roles in the building industry. This analysis adds realism to the expectations placed on market-governed tools and programs for social and environmental improvement in the building industry. Specific recommendation are given to refocus the GBTool.

ROLES AND RULES OF THE BUILDING INDUSTRY

Sociology describes individuals behavior in terms of *occupying* and *performing* "roles". The sociologist R.W. Runciman (1998) likens this to the role played by an actor, with the exception that in real life the actor doesn't chose the script but is simply given a position. The roles are governed by a set of *existing* rules that the actors must acknowledge, even if there is a desire for change. The rules determine how the actors relate to one another and reinforce the limitations of each role. Roles are "governed by rules which the people who occupy and perform them have no choice but to take as given – even if they would like, and accordingly sometimes try, to change them" (Runciman 1998, p3).

The practice of building has a familiar set of roles: developer, financier, designer, technician, builder, regulator, researcher, purchaser and occupier. Different building types may use a different combination of roles, but the rules remain the same. The market is theoretically structured to provide the user or consumer with buildings according to their demands. This means that many specialists are coordinated through defined roles to meet consumer needs. The confidence in this system depends on the rules that govern the roles: if the market defines the roles then the confidence rests with the market. This raises the question of the markets ability to address environmental concerns.

It is noted in the book Natural Capitalism that the twenty-five or so parties involved in a typical large real estate deal are "systematically rewarded for inefficiency and penalized for efficiency" (Hawkin *et al* 1999 p 92). This set of rules is unlikely to inspire the confidence of any one party in the building industry aiming to promote environmental performance, including those hoping to implement the GBTool.

Yet structuring the market to become more eco-efficient is not the complete answer and does not fully grasp the concept of the *"role"* and its context. It is noted in the introduction to Natural Capitalism, "Without a fundamental rethinking of the structure of the reward system of commerce, narrowly focused eco-efficiency could be a disaster for the environment by

overwhelming resource savings with even larger growth in the production of the wrong products, produced by the wrong processes, from the wrong materials, in the wrong place, at the wrong scale, and delivered using the wrong business models" (Hawken *et al* 1999 px). Eco-efficiency is a 'means' tool and not an 'ends' tool and at best will optimize parameters in the existing market structure. If the market is divided into components, eco-efficiency will optimize each component and not the whole system performance. This is known as the 'error of sub-optimization' and the building industry provides a classic example – the trade-off between operating and capital costs.

IMPLEMENTATION OF THE CURRENT GBTOOL

The implementation of the current GBT is limited by its dependence on the market. As noted by the above quote, the use of cost savings only partially addresses environmental concerns. The limitations of the market need to be further examined to direct the GBTool to an effective decision making process. Issues to be considered include how one role shifts its costs onto another, as in the case of capital and operating costs as well as the nature of externalities, collective issues and the environment.

In the market, business is intended to use the profit motive and competition to meet the needs of consumers. The profit motive directs that an activity will not be undertaken unless it earns money for those providing the good or service. This role does not include any mention of environmental or social issues. The single equation of business makes it difficult to consider, let alone optimize, any other parameters. Good environmental and social outcomes may arise from business but only if it also results in a profit. In a market analysis, this leads to the role of the consumer as the driver of social and environmental issues. However, the average individual consumer does not operate in isolation of the market or with a large influence as an individual. Limited funds put economic issues high on the individual's decision framework, regardless of social and environment concerns.

Eco-efficiency is the likely approach of the individual acting alone in the market. Eco-efficiency does not direct a change in behavior but simply makes the existing behavior more efficient. Existing issues, such as habitat destruction, biodiversity loss, resource extraction and human rights abuses in the majority world, are not within the scope of eco-efficiency and never will be. The invidualistic approach of the consumer means that there is the potential for some individuals to follow ethics for the common good, regardless of the financial disincentives. However, it is only when the majority of consumers acts on this ethic that impacts from the collective can be avoided. This is the nature of a collective problem such as environmental deterioration. The impact arises as a result of many individuals and it needs to be addressed by coordinating the actions of individuals.

In the context of the market, the implementation of the GBTool has two possible paths. Either it changes the context within which the roles are performed, or it changes the roles themselves. The GBTool can do both, and due to the relationship between roles and context, both are probably necessary for the GBTool to be effective.

By changing the context within which it operates, the GBTool can educate all connected to the building industry of the environmental performance of buildings. This may make a common understanding of the impact of buildings and develop a common belief of the need to reduce the environmental impact. However, the rules dictated by the market still exist and it is difficult for most to change their behavior in this context. The increased sophistication of the GBTool will bring further confidence to the understanding of the impact of buildings.

However, relatively few individuals are using the GBTool and the impact of buildings in societies has already been documented. Malin *et al* (1995) noted that buildings have a large impact on the environment and account for an estimated 30% of all raw material use, 42% of all energy use and 40% of all air emissions .

A general change in understanding will not affect people's behavior unless it changes the rules that govern the roles. A detailed understanding may even be considered superfluous unless the rules can be changed to allow people to act on the information. In any case, the only way to predict the success of this approach is to examine its track record. Since its development some years ago, the GBTool has not been the subject of much concern by the building industry, with only few knowing of its existence let alone attempting to use it.

NEW FOCUS FOR THE GBTOOL

The future development of the GBTool should focus on existing roles that have some flexibility and are the focus of decision-making. The role of the designer is the obvious market example, while the role of the government, which has a tendency to be overlooked by the economic rationalist, is the non-market example.

The process of design involves creativity and can choose materials that are known to have low social and environmental impacts. The synergy between materials and the performance of the design gives the designer the opportunity to consider issues beyond the usual considerations of the market. Ultimately, the designer is still restricted to the rules of the market and eco-efficiency, but the ability to address issues is heightened. The limitations imposed by the market on the designer can be so severe that only the government can play a useful role to facilitate better design.

The reported success of the C-2000 Program for Advanced Commercial Buildings (C-2000) by Natural Resources Canada is worth examining to understand the flexibility of practice for the designer and the severe limitations of the market. Due to the market slowness to address environmental concerns, the Canadian government financed a design process that would improve environmental performance at little extra cost to the project and, in some cases, savings (Larsson 1998). A requirement of receiving the design funding was the participation in a new design process that aimed to meet defined targets and required documentation of how targets were being met. The project has been successful because it uses (minimal) funds to increase the design budget beyond the market expectation and so allows the designer the time, money and process to consider a new range of issues. Perhaps the program achieved such good results because the market is not as innovative as many economic rationalists believe and so there is much scope for improvement with a little guidance and assistance from government. For example, in the Australian building sector, where innovation is historically low and the industry described as "reactive" rather than "proactive" (Lenard *et al* 1996), it is unlikely that the industry will develop and trial new design processes of it own accord. This is a point contrary to the theme expounded by Amory Lovins in the Australian promotional tour of Natural Capitalism, when he claimed, "I think we're fortunate that in a world where the majority of the 100 biggest economic entities in the world are no longer countries but companies, it's tilting more and more that way, corporations have perhaps uniquely the leadership, skills, speed, innovation, agility and motivation, namely profit, to solve some big problems in a hurry." (quoted in Australian Broadcasting Corporation 2000)

In the Australian market and those that share a similar context, there is a danger of overemphasizing the scope and ability of the market, which has difficulty implementing eco-

efficiency let alone broader environmental issues. Rather than celebrating the dominance of the market it may be worth turning attention to the role of government. For example, the use of government in the C-2000 program suggests that the traditional role of government addressing collective issues does not conflict with market roles. In contrast, it is simply not the role of the market to fully address collective issues or in the case of the Australian building industry, correct its own barriers to efficiency. The Canadian governments role in the C-2000 program was pivotal in implementing improved practice in the Canadian building industry. The following diagram simplifies the building market to its main focus. This emphasizes the limitations of the GBTool by using market implementation and not including building practices. In the building life cycle the main focus of the market is on capital cost due to investment criteria and limited individual consumer funds. In the spectrum of decision making, the main focus of the building market is on demonstrated practice perhaps due to slim margins and tight timelines. This results in only some cost effective solutions being implemented, which in turn only represents a fraction of the social and environmental issues to be considered. It is proposed the role of government is used to achieve the potential of the market and to expand the scope to consider broader environmental concerns.

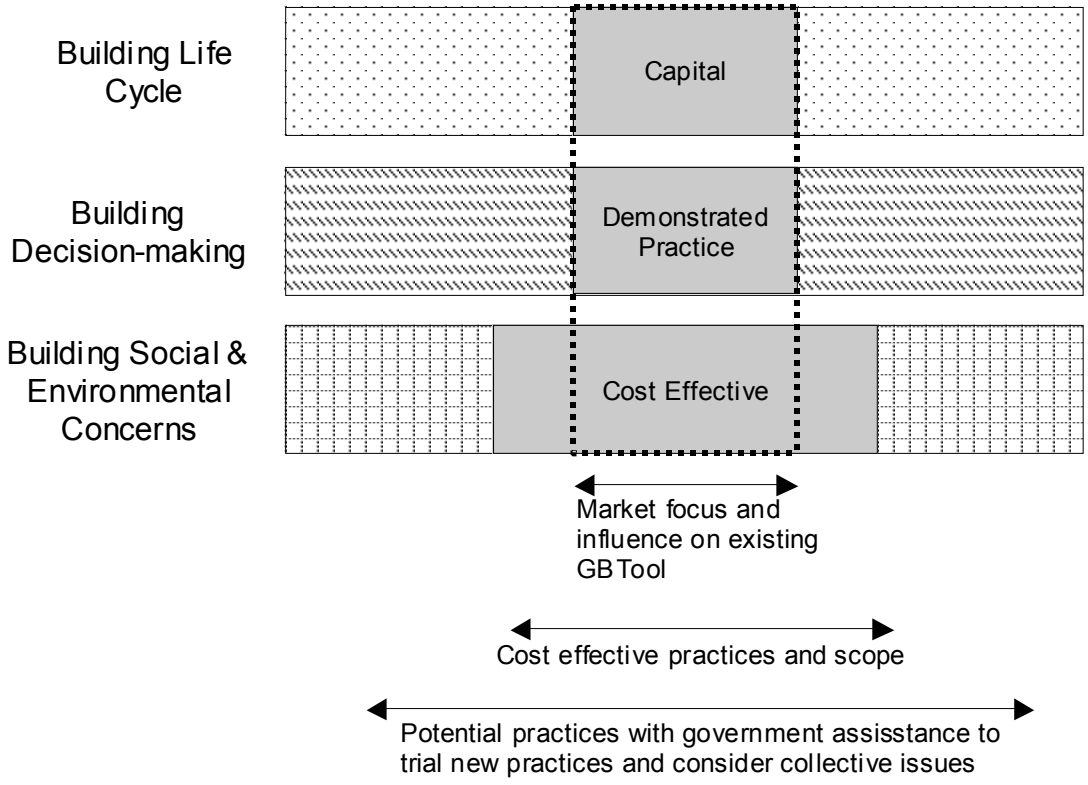

Figure 1 GBTool, market focus and the role of government for changing building practice

INTEGRATING THE GBTOOL WITH THE ROLE OF THE DESIGNER AND GOVERNMENT

It is suggested that the GBTool provide a simple assessment of the *design process* that can be funded and the scope expanded by government. The C-2000 program shows that it is possible to introduce new ideas into the design of buildings. This approach could be expanded to consider issues such as biodiversity in the same way as energy was considered in the C-2000

program. The depth of issues considered in the design process will become the basis of the new GBTool rating. This changes the existing GBTool to provide an audit of the resulting building performance and to set performance metrics for the design process. This change in the GBTool is captured in the shift in focus from quantitative to qualitative benchmarking – from numbers to practice.

The current GBTool focuses on assessing performance metrics compared to a benchmark. However, in the theory of benchmarking, it is argued that it is more effective to benchmark practices rather than metrics. This is simply because the metrics must be linked to a practice in order for any change to occur (McGeorge 1997). For example, *if* a GBTool assessment reveals poor performance, it is not obvious to the designer *how* to improve the performance. Benchmarking metrics may draw heavily on time and resources by repeating existing practice until the desired level of performance is achieved. However, if the benchmark considers practice, then it outlines a new process and way of acting and so guides the designer to improve performance. It is still worth including design targets that need to be achieved, but it is more important to introduce the change in practice that provides the means of meeting the target. For example, the C-2000 program introduced a new design practice that made it easier to meet the specified target of a 50% reduction in energy consumption compared to the benchmark metric (Larsson 1998). A new GBTool could be a series of practices and targets that can lead the design process and provide a pre-occupancy building rating. This combines the benefits of performance metrics with an outcome orientated process and avoids the lengthy assessment procedure. It also draws attention to the role of government to trial new practices as well as support issues that are beyond the scope of the market.

CONCLUSION

It is important to recognize the existing GBTool as a useful program that has educated and explored the issues of environmental building performance. It has facilitated international cooperation, promoted awareness of environmental issues and begun the definition of best practice. However, in terms of facilitating change, the GBTool is like the proliferation of tools that measure or rate improved environmental performance. Although necessary and well-intentioned, they are not well-aimed to change current practice. It is now time for the GBTool program to focus on benchmarking the *practices* that constitute *best practice* and use performance metrics to provide design targets. This will streamline the GBTool assessment and make it more affordable as well as outcome-oriented. The GBTool can evolve into a more useful tool by being linked to the government's role of addressing collective issues and the markets inability to achieve eco-efficiency. This approach is more realistic of for the roles of the building industry and supports the designer to implement new and important environmental practices.

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Development of a Sector Sustainability Strategy for the UK Steel Construction Industry

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1. INTRODUCTION

The need for Sustainable Development is based upon the premise that our planet has finite limits to its capacity for self-regeneration and that human activity is currently damaging the complex life-supporting systems of the planet. When combined with the doubling of world population every 40 years, and the doubling of material consumption every 20 years, the need for international policies to support sustainable development becomes even more urgent.

In the past 15 years, the concept of Sustainable Development has gained worldwide recognition, following publication of the United Nation's document "Our Common Future" [1]. More commonly known as the Brundtland Commission report, this publication defined sustainable development as "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Moreover, sustainable development provides the framework for dealing with social and environmental issues, along with economic objectives, to ensure support for our quality of life in the long term.

In 1999, the UK Government set out its policies for developing a more sustainable future, by issuing the publication 'A better quality of life - a strategy for sustainable development for the United Kingdom'[2]. Sustainable development was defined as that 'which ensures a better quality of life for everyone, now and for generations to come'. Individual market sectors and trade associations were encouraged to develop strategies for their sectors on the basis that they would provide a framework to help the sectors identify and manage economic, environmental and social risks, in an integrated way, and this would unlock opportunities to improve competitiveness and enhance reputation.

In the UK, the Construction Industry was identified as a critical industry for achieving sustainability, partly because of its significant contribution to the UK economy but also because of its considerable environmental and social impacts and, hence, its potential for delivering major improvements. In April 2000, the UK Government published a strategy for more sustainable construction entitled 'Building a better quality of life'[3], in which it set out its own expectations for the construction industry in relation to sustainability. The document demonstrated how the government itself would act as a driver for implementation (through its own procurement policies), by providing guidance to the construction industry on sustainability themes, such as:-

- Re-use of existing built assets
- Design for minimum waste

- Aim for lean construction
- Minimise energy in use
- Do not pollute
- Respect people and their local environment

As a consequence, many companies involved with construction are now taking on-board the issue of sustainability and are developing corporate management strategies to ensure that they address the economic, environmental and social impacts of their core business activities. In addition, contractors are starting to place requirements on their sub-contractors and suppliers to address sustainability and to meet specified standards of performance.

To help individual market sectors develop their own strategies, the UK government has established an independent advisory body called the Sustainable Development Commission (SDC); this was set up in October 2000 with Jonathan Porritt as the Chairman. A government sponsored Pioneers Group has also been established by DTI (Dept. of Trade & Industry) & DEFRA (Dept. of Environment, Food & Rural Affairs); it consists of approximately twenty organisations/sectors that are committed to developing and implementing sustainable development strategies for their own sectors. It currently includes representatives from both UK steel manufacturing & steel construction.

2. STEEL SECTOR STRATEGY

The steel construction sector was approached by DTI/DEFRA, in Autumn 2000, and invited to develop a sector strategy document for the industry. Clear benefits were identified including issues such as setting new industry standards for sustainability, benefiting customers and consumers alike, as well as improving the reputation of the UK sector, both domestically and internationally.

The body responsible for preparing the Steel Sector Strategy document is the SSCSC (Steel Sector Committee for Sustainable Construction). Roger Plank, who is Professor of Architecture/Structural Engineering at the University of Sheffield, chairs the committee; it also includes members drawn from the Steel Construction Institute (SCI), the British Constructional Steelwork Association (BCSA) and Corus. The committee representatives are all committed to dialogue with their colleagues, members, affiliates and clients to ensure comprehensive stakeholder consultation. The SSCSC has strong links to the Pioneers Group, with three representatives attending their meetings.

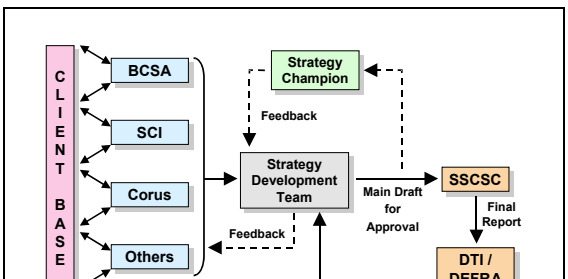
To assist with the generation of sector strategies, the Pioneers Group, supported by the SDC, has issued guidelines on the preferred structure of SD strategy documents; ideally, they should comprise four parts, as follows:

A. Acceptance and understanding of the key principles of sustainability
B. Assessment of current performance
C. Adoption of objectives, targets and indicators
D. Actions to achieve targets and objectives

The Steel Sector committee has adopted this format in drawing up the sector strategy document.

2.1 Organisational Structure

In generating the sector strategy document, it was essential that involvement should include supply chain contributors and other sectors that interact with the steel construction industry. The framework devised for developing the strategy is shown in figure 1.



A strategy champion was identified early in the initial phases, to assist with the development and promotion of the strategy across the client base. The main contributors (SCI, BCSA & Corus) have conferred with their client base and, from these discussions, contributions have been developed for the four parts of the strategy document. A strategy development team is collating these ideas into an initial draft document and feedback is then being sought from the principal contributors and other stakeholders. A revised main draft will be passed to the full SSCSC group for final approval, after which the strategy will be submitted to DTI/DEFRA for their endorsement.

2.2 Key Principles of Sustainable Construction

Whilst it was accepted that the general principles of sustainable development were well understood, and should include social, economic and environmental aspects, there was still a need to develop a more specific understanding of sustainability for the construction sector. In developing this extra understanding, the potential contribution and opportunities of the sector could be more clearly defined and practical steps could be made towards improvements. The following ten principles were developed by the sector as a framework towards this goal; they can be applied to all construction activities but, in the present context, have a particular emphasis for buildings:

Functional Performance and Social Impact: Buildings should add to the quality of life by providing the right combination of aesthetic appeal, functionality and ergonomics to serve an intended purpose. Occupants should have a feeling of well-being and security, for example, through efficient use of space, lighting and ventilation. Aspects of the building productivity and other social interactions should be addressed in the design.

Resource Efficient Design: Designs should consider aspects of resource & energy efficiency, waste minimisation, and other environmental issues (such as preservation of bio-diversity), with regard to the building materials, the construction process, through-life use and end-of-life re-use or recycling.

Informed Decision Making: Information should be made available to help informed decision-making throughout the supply chain, including environmental information on operations, products and services.

Flexible & Adaptable Designs: Materials and structural systems should be specified which allow flexibility and adaptability, to meet future changes to the building function and also to facilitate re-use and recycling of materials at end of life. These aspects will assist with economic impacts and the prudent use of resources throughout the building life cycle.

Economic Efficiency: Where appropriate, the speed of construction should be considered as a factor in realising the economic exploitation of the building. The fabrication and construction of the building should be managed to cause minimum disruption to the economic activities in the locality of the site. Consideration should be given to the speed of construction and off site fabrication possibilities to facilitate this. Efficient, just-in-time delivery of materials and other supply chain dependent issues should be built into project management milestones.

Innovation: The industry should develop innovative, cost-effective solutions that improve quality of life (e.g. to provide housing/safe dwellings in areas of social deprivation) and maintain a physical and social infrastructure that will meet the needs of whole communities in the longer term.

Through-Life Economics: At the design stage, consideration should be given to through-life-costing of the building, including the costs of manufacture, construction, operating, dismantling and disposal.

Environmental Impacts: Due consideration should be given to the environmental impacts of the construction process stages. Emissions to air, water and land, together with waste and

noise should be minimised through the adoption of adequate controls and environmental management systems.

Ethical & Social Responsibility: Employers and businesses, at each point in the materials manufacture, construction and demolition stages should adopt good practices with regard to the social well-being, safety and training of the workforce and their communities. Policy and procedures should be in place to monitor and set targets for improvements. Examples of socially responsible policies include transparency of employee rights, staff retention rates, equal opportunities, the provision of adequate pension schemes and involvement with community initiatives and environmental groups.

Transparent Reporting*:* Transparent, validated reporting of financial/economic, social and environmental issues should be adopted, encouraging equity and fair business practices.

2.3 Assessment of the Steel Construction Sector

The Steel Construction sector has an annual value of £3.5 billion (~ 5% of UK construction activity) and employs approx. 42,000 people. The industry's output has remained steady over the last few years at just under 1.2 million tonnes. Steel's dominance as a framing material continues, especially for multi-storey buildings, with speed of construction being the number one reason for choosing steel, followed by 'lowest overall cost'. The latest figures show a total market share at nearly 70%, with the greatest usage in multi-storey industrial applications (92%) and in non-domestic single-storey buildings (90%).

Activities in the sector already make a major contribution to sustainable development. For example:-

- ***Re-use/Recycling***

Steel can be either re-used or fully recycled. An excellent example of the re-use option is shown in figure 2. At the end of its 'first life', this tower block was stripped back to the original steel frame, rather than being completely demolished. It was then refurbished using the steel framework as a starting point. In situations where re-use is not feasible the scrap steel can be collected and sent for re-melting at the steel plant. Current evidence suggests that 95% of UK constructional steel is recovered with 10% re-used & 85% recycled.



Figure 2 Refurbishment of Winterton House using existing steel framework

- ***Product life-cycle information*** The steel construction sector is able to provide detailed life-cycle inventory (LCI) data on steel products up to the factory gate and, also, during the application of those products in buildings (e.g. LCA studies on the environmental performance of buildings). This information is available from Corus[4] and IISI, through a range of projects being carried out within the sector organisations.

- ***Design Guidance – brochures*** Extensive design guidance literature is available through the Steel Construction Institute (SCI) and also IISI. The literature recognises the opportunities offered by the good strength to weight ratio of steel, as well as the wide & unique range of steel products that are available for the construction industry. Through

this information, the steel sector is enabling architects to develop buildings that have good functionality and are visually appealing. It also facilitates the concept of lean manufacturing in product design (i.e. efficiency of manufacturing).



- ***Functional Performance and Social Impact*** The Cardiff Millennium Stadium (figure 3) is a good example of how steel can be used to generate a structure with high social impact. The long spans





Figure 3 Cardiff Millennium Stadium showing interior and external views

permitted by steel give a feeling of spaciousness and well-being, with un-interrupted views of the central pitch area. The innovative sliding roof is supported by a tubular steel structure and this allows the stadium to be adapted for different events and weather conditions.

- ***Resource Efficient Design & Environmental Impacts*** Modular housing systems (figure





Figure 4 Conventional housing design utilising modular steel framework

4) allow the steel frame to be manufactured off-site, thus avoiding waste at the building site and minimising other impacts, such as noise and dust. Pre-fabrication off-site also allows more efficient use of resources. Modular housing provides flexibility both during construction and throughout the life of the building. Composite walls provide excellent thermal properties making designs highly energy efficient.

- ***Economic efficiency***

Figure 5 Sainsbury's supermarket

Supermarkets and other retail outlets require speed of construction to permit full economic exploitation of the building. Designs in steel, such as the Sainsbury's supermarket shown in Figure 5 facilitate this. The building won a Corus Design Sense award in 2001, for its resource efficient design. The low energy building uses

natural lighting and renewable energy sources of solar and wind power. At the award ceremony it was stated that the Greenwich store had achieved the highest satisfaction rating for any Sainsbury's store, with both staff and customers.

2.4 Strategy for Future Progress

The preceding examples demonstrate that the UK steel construction sector is already contributing significantly to the sustainability agenda. In developing the sector strategy, further opportunities are being identified mainly through collaboration with stakeholders and scenario planning, which has given an increased understanding of the changing market needs. Examples include:

- Alignment with markets by understanding the stakeholder views
- Overcoming of barriers to supply chain efficiency
- Understanding the full life-cycle impacts of steel in construction
- Exploiting the opportunities in the context of sustainable development
- Targeting improvements through innovation and system solutions

Work is ongoing to develop metrics to monitor progress of the sector against social, environmental and economic aspects. By identifying Key Performance Indicators (KPIs) that are influenced by the sector, it will be possible to set targets and report this progress to meet stakeholder expectations. Within the Pioneers' Group there is a recognition that KPIs need to be flexible in terms of describing the trends and progress of the sector contribution. In this respect, the range and selection of KPIs will grow as the needs of stakeholders are developed over time.

3. CONCLUSIONS

Steel already makes a significant contribution to sustainable development within the UK construction industry.

There is a recognition that as the steel sector moves towards more sustainable practices, it must engage in stakeholder issues and align its products and services to meet the new challenges.

Through understanding the principles of sustainable construction, a platform for launching practical measures has been identified and future progress will be monitored using key performance indicators.

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The rehabilitation of sea side harbors in respect to sustainable development on the base of chosen small resort towns on peninsula Hel in Poland

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Introduction

Poland's coastline measures about 540 km and it is divided administratively between three regions, with Western Pomerania and Pomerania, and their capitals in Szczecin and Gdańsk, comprising the main part of Baltic Coast. At present, along Polish coastline 56 ports and havens are located, among which 11 near Bay of Szczecin, 8 near Bay of Wisła and 37 at the coast of the open Baltic Sea. Ports and havens constitute a base for Polish Baltic Flotilla , which consists of about 400 fishing boats and 900 boats. Taking into consideration mainly Pomeranian region it is not only located on the open sea. The agglomeration of Gdańsk – with Gdańsk (the region's capital), Gdynia and Sopot, generally called Trójmiasto – also lies on the so-called "Small Sea", i.e. the Bay of Puck closed to the north by Hel Peninsula.

Vision of Hel's future as a part of mobile(movable) waterfront project.

Hel is situated on Hel Penninsula, borders on both Bay of Puck and open sea. Agglomeration of Gdańsk, Gdynia and Sopot is situated near bay's coastal line as well. Economical transformation of country and its consequences caused that these 3 cities of agglomeration have been developing in entirely different direction and with totally different speed than small porting towns of Hel Pennninsula. Towns like, i.e. Chałupy, Kuźnica, Jastarnia, Jurata, Hel mostly try to make capital of its specific localization, which is especially profitable in the aspect of tourism (access to bay and open sea). The main problem of towns located on the peninsula is deficit of workshops as well as long distance to Trójmiasto (agglomeration of 3 main cities). To reach Trójmiasto, it is necessary to round whole Bay of Puck. Because of that and some other reasons, especially seasonal character of services, small towns of Hel Peninsula have slight opportunities to develop. Recreational and touristic activity on Hel Peninsula is at present a basic source of maintenance for about 55 % people of this terrain. Limited area of Hel Peninsula (34 km of length, min. width of 200 m and max.-3 km) causes that there are no opportunities to constitute new workplaces in other fields than

tourism. For the same reason - area's deficit - development of existing recreation centers is also problematic(Figure 1).



Figure 1. Hel's location with respect to the Gdańsk agglomeration (Gdańsk-Sopot-Gdynia).

On Hel Peninsula that limits Gdańsk Bay at the north, there is situated a wide net of attractive touristic towns, which have their own accommodation and gastronomic backgrounds. However, they are in a deep social and economical regress caused by continuous decreasing interest in the field of local fishing activity as well as in the field of touristic offer of Polish seaside towns (mainly because of low standards and lack of parking places). Typical industrial cities – Gdynia and Gdańsk tightly connected with marine industry distinguish themselves by a lack of ecologically attractive areas as well as existing in the marine context of agglomeration at the same time.

Emphasizing development of very popular nowadays weekend-tourism could be a good idea for activating small towns of Hel Peninsula. Wide accommodation basis could be also therefore exploited outside summer season, when Hel Peninsula is full of tourists of all the country. Pomeranian Region Development Programme for period of 2001-2006 provides, among other ideas, marine short-distance communication development on a base of already existing havens and marinas of Gdynia, Gdańsk and Sopot. (Trójmiasto is a municipal organism situated along bay's coast). Hel Peninsula and whole coast of Bay of Gdańsk is an unique geographic and ecological object. An access to it is provided by dangerous public roads and antiquated railway. Increasing tourisic activity (long-terminal tourism and weekend-tourism), mainly realized by cars, affected on statistics concerning traffic security

and natural environment. An access to towns situated around Hel Peninsula from water side is also limited. This situation constitute a serious blockade against social and economical restructuring of terrains of Hel Peninsula and Puck Bay. It is necessary to make attempt to develop marine communication as an alternative for regular road communication connecting Trójmiasto and small towns of Hel Peninsula, especially the most attractive for tourism –Hel and Jastarnia. It would make an opportunity to avoid environmental destructive and area-absorptive motor transport. Near-coast transport would serve as everyday, regular communication. In the summer season, a wide net of marine connection (frequent and easily accessible) could be an attractive alternative for motor transport, which traffic capacity is always problematic in this period. Further doubtful issue is parking area question, which has its consequence in green terrains devastation. A system of "Park&Ride" which include combining both motor and bicycle transport is planned in area of Trójmiasto. It is previewed that together with marine transport, this system will not only make Hel's region more attractive and accessible, but also will constitute whole organism of this area. Entertainments and performances on a large, over-regional scale would take place in Trójmiasto, as a metropolitan unit, but some of them could be organized on movable ships, which would not be determined by any specific location. Similar projects are being realized thanks to that kind of architects as, i.e. Lifschuts Davison, who designed a swimming pool flowing on Tamiza River or Guilherme Paris Couto who was an author of a project of flowing restaurant. The flowing hotel-ships would compose a touristic base for summer-resorts in the summer time and outside this period would serve as a conference and fair base. There are some planes of building an artificial isle in Sopot and adapting military objects on Bay of Gdańsk for conference center's aims near Gdynia (Figure 2a, 2b); (There exists also a project of "Building touristic base in the area of Bay of Gdansk" prepared according to instructions of authorities of Gdynia, Hel, Jastarnia, Kosakowo, Puck and Władysławowo. Authors of this project intend to constitute wide net of co-operating yachting ports and havens for small boats windsurfing. Furthermore it is said to make some touristic stations connected with platforms for small boats as well.) This type of "boats" could be produced and repaired in small port-towns of Puck Bay, which could be a great support for their port-character and would help to create a new sea-shore image. All of it would constitute some kind of mobile waterfront, which would be entirely new urbane and architectonic issue, which could tie all cities and towns of Bay of Gdańsk.



Figure 2a. Existing military object in Gdynia

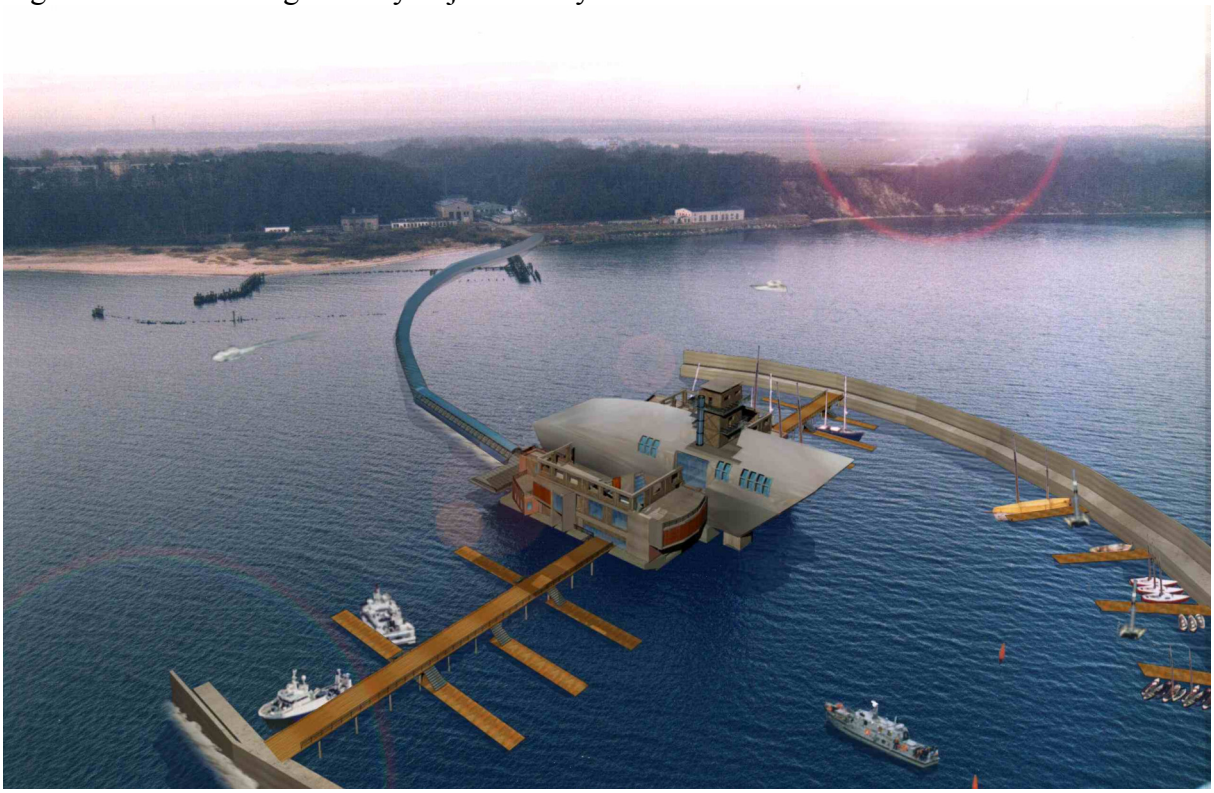

Figure 2b. Revitalization of military object in Gdynia for conference center's aims and marina

Town of Hel as a potential health-resort.

In case of Polish coast, especially Hel Peninsula, apart from necessity of maintaining the port's character of seaside cities, it is very important to make capital of other local conditions, which decide of their attractiveness. A good example could be town of Hel. First mention about fishing settlement in Hel was made by English seaman –Wulfstan in IX century. In XIV century Hel was already a town and an important fishing-center, however without a port. On the turn of the XIX century there appeared a deep regress in Baltic fishing. Hel was devastated and on the whole Pomerania of Gdańsk there was no real fishing port. That is why authorities of Gdańsk decided to build a new fishing port in Hel, taking under consideration its localization as the most convenient for that aim. Considered to be the most marine of all towns in northern Poland, the center of Hel is found 33 km from the northern end of the Hel Peninsula. From the administrative point of view it is a gmina, whose entire area has town status. Surrounded by the waters of Baltic Sea and the Bay of Puck ("Small Sea"), on just 1 km it borders by land with the town of Jastarnia. The development of water tourism and recreation is tied with Hel's location and its development possibilities following a long period when it was eliminated from the map of tourism centers due to military considerations. The climatic and health-resort values predestine the town to be turned into a health-resort. At the moment there are two ports in the town of Hel: fishing port and a navy port. The port in Hel is a sea fishing port, which includes a position for coastal navigation ships and positions for boats. From the west, the areas encompassed by the port's borders are currently being used for services. The fishing port, functioning as a base for fishing cutters and a landing-place for boats was examined by the town's authorities, in a separate form, as a marina. As a result of insufficient space for building the marina's facilities on the site proposed in the "Study...", other proposals have been prepared indicating the possibility of preparing an additional area (an artificial island) for building the marina's facilities along with

a restaurant and coffee bar complex (Figure 3). That could also operate outside of the season , as generally accessible, at the same time forming an element of the costal zone envisaged in the development program. The new location of the boat port taking into account enlarging and changing the character of the present military harbor would make it possible to create a strong center of water tourism complying with both the requirement of sea navigation, and boating. At the moment tourism and recreation in Hel is practiced in various forms – as sojourn recreation – mainly in recreation centers and leased premises in the residential building, as well as holiday recreation (one day, without spending the night) – mainly tied with the functioning of the coastal navigation between Hel and Trójmiasto. Rehabilitation of post-war buildings, a complex project of creating a costal zone, exhibition of the historical buildings with a rich tradition of old fishermen's settlements and making use of the climatic values will make it possible to introduce the environmental values of the Polish natural space of world significance, into the system of European values in such a way as to ensure the protection and utilization of the values of its biological diversity. The opening of the natural resources of Poland's recreational space for the growing demand of Western Europe for practicing not only water tourism, but also various forms of eco-tourism and recreation in natural surroundings, will make it possible to carry out an unfulfilled task of transforming the town into a health resort. A presentation of such a center in a way complying with the requirements of the 21st C. and using the means this century has at its disposal, calls for overcoming resistance of not only the decisions –makers themselves, but also inhabitants, who must find out about the purposefulness of these changes. Therefore, basing on the principles of actively including society in the process of transformations, it is necessary to prepare a project of the future with an exemplary implementation of some of its elements aimed at raising investment attractiveness. Taking into consideration the integration between planning and management with respect to all of subjects of sustainable development, in the case of Hel's development program, they will find their expression in both the methods of managing already invested areas, as well as those intended for constructing new buildings, in protecting cultural heritage in the modernization process, or constructing new building resources. This kind of activity should lead to keep the town for the future, as a town of specific climatic, natural and cultural values, with the possibility of transforming it into a center of water tourism of an international character.

Recapitulation

We present on above-given example of Hel's town the programme of certain undertakings, that particularly contain:

1. enlarging the port, taking into consideration the external preconditions and providing it, as a part of creating a new image for the costal zone, with new significance,
2. preparing a project of coastal zone as a recreational water-land track, using among others the values of Hel's historical buildings from the former fishing settlement (protection of the cultural heritage),
3. creating tourism facilities by modernizing existing buildings and erecting new ones, in accordance with the principles of sustainable development,
4. reactivating the project of creating the Hel Health Resort, which was abandoned before a military fortified region was created here,
5. an analysis of the possibility of reactivating town-forming factors in the forms of the hitherto processing industry as an element of the town's economic activation, is a reflection of the National Regional Development Strategy, adopted by the Local Authority of the Pomeranian Region - the supreme self-government authority in the region – where the main goals and tasks of urban centers of the

Baltic Region, threatened by marginalization, include: ("The Strategy for developing the Pomerania Region – Pomerania Regional Studies, Marshall's Office of the Pomerania Region. Gdańsk 2000)

6. development and modernization of the environmental protection infrastructure,
7. raising the attractiveness of investments in region,
8. development of the tourism sector,
9. mobilization of the entrepreneurial potential in the regions,
10. economic activation of towns where industry has collapsed,
11. development of trans-border co-operation,
12. forming personal and institutional resources enabling Polish regions to effectively co-operate internationally on the basis of partnership.

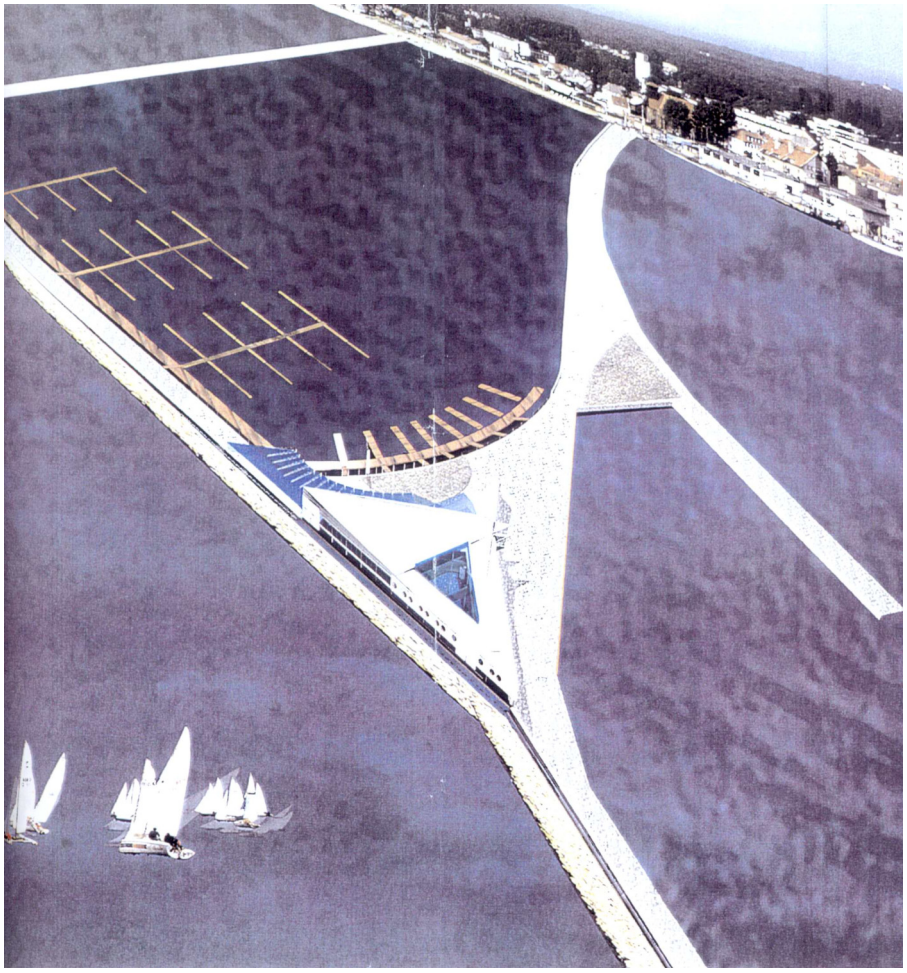

Figure 3. Alternative project of marina on the example of a study of Gdańsk University of Technology

Value Propositions for Green Buildings

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1.0 INTRODUCTION

Proponents of green buildings often resort to rhetoric ("green is good") when advancing their case. But building owners and developers have very different approaches to valuing green buildings. These "value propositions" can include both measurable and non-measurable benefits, both for the building itself and for the organization. Examples of measurable benefits include the life-cycle savings in energy and water consumption from improved building energy performance and an improved marketing positioning resulting from building a green building; non-measurable benefits include intangibles such as public relations benefits to an organization or the prestige of locating one's business in a green building.

Green buildings or sustainable construction projects often involve more expense than conventional construction, especially in "soft costs" for additional design, analysis, engineering, energy modeling, commissioning and certification to relevant standards such as the U.S. Green Building Council's Leadership in Energy and Environmental Design™ (LEED™). These costs may exceed 1% of construction costs for large buildings and 5% of costs for small buildings, depending on the particular measures employed. Higher levels of sustainable building (e.g., the LEED™ "Silver" or "Gold" standard) may involve additional capital costs, based on case studies of buildings in the U.S., as documented in recent studies by the Rocky Mountain Institute (2002) and U.S. Green Building Council (2002).

Justification of such additional costs has traditionally rested on the economic "payback" or return on investment for energy and water conservation measures. Green building standards such as LEED incorporate additional requirements beyond energy and water use, e.g., indoor environmental quality, use of recycled materials and site considerations, so it is increasingly difficult to justify green building investments on the value of such savings alone.

Additional *value propositions* for green buildings are needed to justify the incremental expenses involved. These value propositions may be classified as occurring *inside the building* and *outside the building*. "Inside the building" values may be created by increased productivity of workers, while "outside the building" values may be created by enhanced image of a company or institution. Additional measures of value might include risk management issues, recruitment and retention of key employees, and enhancing the value of real estate investments.

2.0 VALUING GREEN BUILDINGS

2.1 Green Building Rating Systems. Green buildings today have a variety of rating and certification systems available, but in the United States, the *de facto* national rating system is LEED. In certain "vertical market" segments such as secondary schools, modified versions of LEED are being used, for example in California (CHIPS, 2002). These ratings systems are

"point-based" and focus primary on the building itself and the environmental impacts of its construction and operations.

2.2 Benefits of Ratings Systems. Green building rating systems provide some value in the marketplace today, primarily to institutional building owners and developers, such as federal, state and local government; schools and universities; non-profit organizations; hospitals, libraries, etc. These represent >70%, for example, of the first 350 buildings registered under the LEED 2.0 system during its first two years of existence, i.e., through April 12, 2002 (U.S. Green Building Council, 2002). Many private, for-profit building owners have used LEED to evaluate their buildings and to implement policies for sustainability and corporate social responsibility, e.g., American Honda Motor Company's LEED building in Gresham, Oregon. A small handful of private businesses have built such buildings for the benefit of their employees and/or to secure life-cycle cost savings in operations.

2.3 The Value of Green Buildings. The value of buildings depends on the nature of ownership. For example, a major government agency may construct buildings with a 50-year to 100-year life, whereas a property developer may simply construct buildings for immediate leasing and short-term sales potential. Each of these building owners is pursuing different measures of value, and the task for green building proponents is to recognize this state of affairs and to tailor their approaches to different owners accordingly.

Since marketplace values can shift rapidly, depending on the state of the economy, vacancy rates for properties, interest rates, etc., it is difficult to ascribe exact values for various green building measures. For example, in today's low interest rate climate in the U.S., where interest rates are at the lowest levels in 40 years, it is easier to justify longer-term investments in energy and water savings, both for government agencies and private building owners; in other words, the acceptable "payback" can be as long as 7 to 10 years, or more.

Buildings also accrue value by having lower operating costs. In a low interest rate climate, the "cap rate" or multiplier of annual savings to get incremental increases in building value may be as high as 12, whereas in higher interest rate environments, it can shrink to 7. So, the same projected annual savings in energy and water costs, or benefits of productivity increases, might be worth 70% more in a low interest rate economy than in a high interest rate economy.

Marketing benefits might also accrue to LEED-rated green buildings, if they become the standard measure of value for commercial and institutional construction. Such buildings might be easier to lease or rent fully, or they might command higher rents or lease rates. At this time, there is little marketplace evidence that this is the case. If it were easier to lease green buildings, then speculative developers might be very interested, because a fully leased building prior to construction is a very valuable commodity. In addition, many commercial lenders want to see >60% committed occupancy prior to releasing funds for construction.

3.0 COSTS OF GREEN BUILDINGS

3.1 Value is Relative to Cost. Each measure in a green building project has a cost, even if it's just the cost of documenting the LEED rating level. Such professional services, including energy modelling, building commissioning, additional design services and the documentation process, can easily add 0.5% to 1.5% to the project's cost, according to the U.S. Green Building Council (2002). So, green-building proponents might have to find measures by which to value their projects to overcome the additional costs of such projects. Evidence is

increasing that buildings certified at the LEED "Gold" level might add 5% or more to project cost (Ecotrust, 2002).

3.2 Costs Depend on Many Factors. Many of the green building measures that might give a building its greatest long-term value, e.g., on-site energy production, on-site stormwater management and water recycling, "green roofs", daylighting, natural ventilation often require a higher capital cost. While it is possible to get a LEED-certified building at no additional cost, as one moves to make a building truly sustainable, cost increments do accrue. Finding out which costs are going to provide the highest value is a primary task of the architect, working in concert with her client, the building owner or developer.

3.3 Classifying the Value of Green Buildings. The author has developed a classification scheme for understanding and using green building value analysis, as shown in Table 1. Almost all discussions today involve only the upper left quadrant. However, many owners and developers value other attributes of green buildings more highly than operating cost savings.

Table 1. Understanding the Benefits of Green Buildings

Type of Benefits/Where They Occur	Measurable	Un-measurable/Intangible
Inside the Building		
• Economic • Non-economic	Energy/Water Savings Increased Employee Well-Being/Productivity	Increase in Building Value Increase in Morale
Outside the Building		
• Economic • Non-economic	Marketing and Sales Retention/Recruitment	Brand Identity Public Relations

4.0 MEASURABLE BENEFITS OF GREEN BUILDINGS

Tables 2 shows a variety of measurable benefits, occurring both inside and outside the building, according to a classification scheme developed by the author.

4.1 Benefits that Accrue to the Building Itself. These costs are fairly easy to measure and include the usual energy and water savings of well-designed buildings, of which there are many examples, such as the 200 cases documented by Rocky Mountain Institute (2002). Other benefits might include resale value, owing to such savings, as discussed above.

4.2 Benefits Related to Building Occupants and Their Behavior. There is a growing body of literature, compiled most recently by Loftness, Ries and Mondazzi (2001) of the very real and measurable benefits of buildings that have enhanced daylighting, natural ventilation and improved indoor air quality. These benefits are found in such areas of concern as enhanced productivity, reduced absenteeism and illness, and improved retail sales.

4.3 Benefits that Accrue to the Organization or Building Owner. Green buildings may also yield benefits to the building owner, for example, through higher rents, better tenants or longer-term leases from quality tenants. These immediate benefits might also translate into a higher resale value, since the resale value will typically be a multiple (the "cap rate") of the

projected annual cash flow generated by the building. Additional benefits might include sizable tax credits for green buildings that are being offered by several U.S. states.

4.3.1 Reducing Costs for "Churn". For long-term owner-operators such as government agencies and large corporations with open-plan offices, green buildings measures such as underfloor air distribution systems (raised or access floors) may reduce costs of *churn*, the incessant propensity of such organizations to move people's work areas, typically at rates of 20% to 30% per year. Savings of up to USD$2,500 per workstation in moves have been reported at various conferences, or about USD$25/$m^2$, based on an average workstation area of 10 m^2 per person. If the underfloor system adds a net cost of $30/$m^2$ to the initial cost of the project, then that cost is nearly recovered in the first full set of moves. Meanwhile, the benefits of reduced energy costs and healthier air accrue to the project.

Table 2. Examples of Measurable Economic Benefits Inside the Building

Type of Benefit/ Building Owner	Energy Savings Investments	Water Savings Investments	Productivity Enhancements	Sales Enhancements
Commercial				
• Speculative	Justify only with higher rents	Justify only with higher rents	Must add to sales value	Not likely
• Owned	Reduce operating costs	Reduce operating costs	Add daylighting & views outside	Add daylighting to retail
Non-commercial or governmental				
• Owned • Leased	Reduce operating costs	Reduce operating costs	Reduce no. of employees	Not applicable

5.0 NON-MEASURABLE OR INTANGIBLE BENEFITS OF GREEN BUILDINGS

5.1 Benefits that Accrue to the Building Itself. Most intangible benefits accrue outside of the building operations. A few of these are shown in Table 3.

5.2 Benefits that Accrue to Building Occupants. Many employees may feel benefited by the enhanced prestige of working in a well-known building, or may have higher morale owing to the better physical and psychological environment. This has always been the goal of architects, but only recently have there been the tools for analysing and simulating daylighting and natural ventilation, for example.

5.3 Benefits that Accrue to the Organization or Building Owner. This area reflects many of the primary benefits of green buildings, and most of the benefits are intangible. Some of these are brand image, public relations, enhanced marketing capability, market positioning, reduced risk of lawsuits, employee loyalty and attractiveness to new employees, fund-raising capability, "doing the right thing," and the like. While these benefits are "intangible," they are nonetheless "real," in the sense that they do have economic or social value.

5.3.1 Brand Image. Large corporations are highly concerned with brand image. Recent green building projects by such large consumer products companies as Ford Motor, Honda America, Gap (clothiers) and many regional and national banks, all serve to indicate the importance of brand image and the role that green buildings might play in enhancing it.

5.3.2 Public Relations. Many public agencies have sought to demonstrate their commitment to sustainability through the construction of green buildings, including the U.S. General Services Administration, which owns or operates more than 50 million sq.m. of buildings. Other public agencies with strong green building programs include the State of California and the City of Seattle, Washington, which have each committed more than USD$400 million to LEED "Silver" certified new building construction in the next few years.

5.3.3 Enhanced Marketing Capability. One local residential remodelling company in Portland, Oregon, has built a new LEED-certified building with a showroom for consumers. In the process, it has garnered considerable publicity for the company and has built a reputation as a place to go for certified wood products in cabinets, according to Kelly (2002).

5.3.4 Market Positioning. The author has worked with a small (2000 student) private university that is considering a green building program. During the course of a green building *charrette*, it became apparent that the university could "re-position" itself in the marketplace for students in its local area, from its current image as a place for teacher training to a much more progressive "sustainability" image, through both building design and a conscious effort to integrate sustainability into the curriculum. The economics of such a re-positioning are attractive: at the margin, each new student paying full tuition generates a gross revenue of USD$80,000 to USD$100,000 over a four-year college program, with almost no margin cost for serving that student – the university will hire no new instructors or build any new classrooms for a handful of new students. If enrolment were to grow just 0.5%, i.e., 10 new students, as a result of a LEED-rated building program, revenues would increase by more than USD$800,000. This revenue gain would support any extra costs of a green building program.

5.3.5 Reduced Risk of Lawsuits. In the litigious climate of the U.S., employers would do well to consider how a documented improvement, according to accepted "best practices", as exemplified in LEED and related standards, might serve as a defense in a lawsuit, for example, alleging "Sick Building Syndrome" as the cause for an employee's illness or harm. How much better a defense would this be than merely citing the building code as the rationale for mechanical and building systems design? In addition, it is possible that, over time, this reduced risk of lawsuits, might allow insurance companies to offer lower rates for such buildings. Thus, a risk management approach (intangible benefit) might eventually result in tangible economic benefit.

5.3.6 Employee Loyalty and Attractiveness to New Employees. Many organizations seek to demonstrate their commitment to employee health and welfare through a variety of benefit programs. Companies and agencies are now beginning to view green buildings as a tangible and positive statement of their long-term commitment to employees' health and well-being. Employees can also be expected to see such benefits as "real," especially when the employer takes care to communicate what it is doing and how the building is better. One may also conjecture that the prospect of working in a well-known green building might, at the margin, also be a powerful attractant to high-level professional employees. At a current cost of USD$30,000 to $150,000 cost to recruit, hire and train a new high-level employee, this intangible benefit might well yield positive results. As another example, with explosive growth in population of secondary students now underway in the U.S., there is a growing teacher shortage. Would it be possible for school districts with new schools offering the best in daylighting, natural ventilation, controllability of classroom environment, etc., to attract better teachers, compared with those schools than can't offer such amenities?

5.3.7 Fund-Raising Capability. Consider the case of a small private university, cited above, with a limited base of charitable donors, typically limited to local business people and alumni/ae. This university feels that a green building program can help it tap a new base of donors, not only for the buildings, but for the university's new "sustainability initiative." This

need to "walk the talk," creates opportunities for green building advocates to help universities and non-profits such as Ecotrust (2002) to build leading-edge projects, by working with them in the fund-raising arena. An excellent tool would be a fund-raising prospectus highlighting the benefits of the green building and the commit to sustainability it represents by the organization.

5.3.8 "Doing the Right Thing." The green building literature is replete with examples of projects moving ahead, because the owners or developers realize it's the "right thing" to do. Unabashed altruism is still present, even in the commercial building industry, and organizations that want to stay on the leading edge of change recognize increasingly that their building programs reflect on their character. In the oft-quoted words of British statesman, Sir Winston Churchill, "we shape our buildings, and then our buildings shape us."

Table 3. Examples of Typical Intangible Benefits Outside the Building

Type of Building/ Benefit	Public Relations	Public Policy	Marketing and Sales	Company or Organization Brand/Image
Commercial				
• Speculative (developer)	Not very important	Not applicable	May help with loans or leases	Could be useful for developers
• Corporate-owned	Very important	Not applicable	Very important	Very important
Non-commercial or governmental				
• Owned	Very important	Crucial	Not applicable	Very important
• Leased	Very important	Crucial	Not applicable	Very important

7.0 CONCLUSION

In this paper, the author has argued that green building advocates, mostly architects and sustainability mavens, need to learn and use the language of business in order to be more effective at market transformation. This language includes of course, economics and finance, as exemplified in "return on investment," future value of buildings, productivity, etc. However, the non-economic and intangible language of business, found primarily in marketing, risk management and public relations, needs to be equally emphasized. In fact, it is often the driving force for key business decisions.

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The Local Agenda 21 for Old Aleppo: Towards a sustainable urban settlement

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1. INTRODUCTION

The City of Aleppo, with its two millions inhabitants, is considered as a metropolis for the northern regions of Syria. The core of the City evokes the long history in which Aleppo is proud to be one of the longest continuously inhabited city in the world. Modern interventions have introduced wide streets, cut across the historic urban fabrics that resulted in the demolition of a part of the Old City as well as a great loss of its residential units. In 1986, Aleppo's Old City was declared a UNESCO World Heritage Site. Later, in 1992, the City initiated the Project for the Rehabilitation of Old Aleppo with the involvement of the German Government (GTZ) and the Arab Fund for Economic and Social Development as partners.

The Rehabilitation Project has for objective to preserve the Old City as a living entity and to stop further deterioration. The *Development Plan*, adopted by the City, delineates integrative approaches and strategies for upgrading the historical urban tissue. The methodology includes various aspects of urban management that cover the following main tasks: planning, housing micro-credits, urban environment, urban economy, social development, information technology, traffic and infrastructure.

2. SUSTAINABILITY AND THE LOCAL GOVERNMENT

Sustainable Development has been suggested as a mean of integrating economic and social development with the fundamental protection of the environment. The major catalyst has been the UN conference in Rio in 1992 and the series of UN conferences that followed like "Habitat II" in Istanbul in 1996. The basic characteristics of sustainable development like: Environment, Social equity, Human economy, Futurity, Participation, etc. permit to investigate on the terrain the potential role that the local government, represented by the City Council and the Municipality, has to take part in.

The Municipality has a major role to play in promoting sustainable development, little can be delivered without its commitment and cooperation. To achieve sustainability, the Agenda 21 is considered as one of the most primordial tools, it is an interactive process in which the Municipality has a key role as an initiator and caretaker of its progression. There is a big need for partnerships and for consensus within the civil society at each stage of the process. To conclude, the Local Agenda 21 is a solutions oriented process, focus on action and committed to continuous improvement.

3. THE LOCAL AGENDA 21 ACTION PLAN

A Local Agenda 21 action plan is something different from all previous plans, it stresses the importance on integrating environmental with social and economic considerations, on having a vision to the long term and objectives and look beyond the time a horizon of most existing plans, on preparing programs to achieve these objectives and recommend steps to encourage

action and implementation, and on tackling simultaneously local and global issues at the local level. Moreover, the action plan shall involve the analysis of immediate priorities, a clear implementation plan and the development of a monitoring system as well as a communication strategy.

3.1. The Old Aleppo action plan

The urban management in historic sites acquire an additional level of importance and complication which the Local Government has to face in its daily work. Strategies should cover all possible levels of urban interventions and study the interaction between human and the traditional fabrics to be considered as sustainable. As mentioned above, the Project for the Rehabilitation of Old Aleppo has covered the main aspects of urban management, they correspond to several chapters in the Agenda 21, and presented with projects and activities in which the Rehabilitation Project is involved as well as planned activities to be undertaken for the future. They are presented as part of the respective chapters of the international Agenda 21 documentation.

3.1.1 Chapter 3: Combating poverty

Shibani School VOCCAD centre

This project constitutes efforts which are exerted to rediscover a large forsaken monument "The Shibani School" to improve social and cultural infrastructure and to integrate new functions in it to help revive the cultural spirit in Old Aleppo. The Objectives of the Project is to establish a centre for the training on the applied arts especially restoration techniques (VOCCAD). The method of this school is "learning by doing", thus, the restoration of any adequate building can be done by the trainers themselves according to the stage of progress.

Traditional techniques of all kinds of crafts are vanishing slowly, because modern techniques of conservation are unknown among local professionals. There is an increasing demand for adequate renovation work, therefore, the purpose of creating this centre is to train young professionals on renovation works, push them to a higher level of technical restoration skills and consequently increase their job opportunities.

3.1.2 Chapter 4: Changing consumption patterns

Environmental Management in the Small and Medium sized Enterproses (SME)

The project main objective, under a short-term perspective, is to help SMEs improving their environmental performance and management as a step with regard to the environment in the Old City. This will engage the promotion of new production process and might necessitate the introduction of new techniques. Likewise, under a mid-term perspective, the fund shall provide experience for future broader public support to SMEs, it intends, under a long-term perspective to sustain investments and measures to improve the situation of environment in the Small and medium sized Enterprises (SME) in the Old City of Aleppo.

In fact, this process will enable the Municipality to build experience in the field of public SME promotion as well as cooperation between the Municipality and the private sector in order to promote the idea of the Public-Private-Partnership (PPP) between enterprises and local authorities. The grant of the SME promotion can be considered as a new tool for managing the environment and the economy. Through this fund we can: show the rationale of SME promotion within the context of the Old City rehabilitation, provide an orientation for the project team on how to manage the SMEs fund, and produce guidelines for urban SME promotion to be disseminated either to further SME promotion in Aleppo or to other interested Municipalities in Syria.

3.1.3 Chapter 5: Demographic dynamics and sustainability

Housing strategy

It is estimated that the Old City of Aleppo contains some 15000 residences of various types. The Project has undertaken some support measures to encourage the residents in stabilizing and modernizing their homes through various fund programs (emergency and rehabilitation funds). However, the Project's interventions have been limited in scope. The Project is concentrating on developing a multi-faced housing strategy that will encourage all stakeholders and concerned agencies and institutions to develop additional procedures to support housing. These will include the cooperation with several institutions as well as redesigning the existing already available funds.





Photo1 Example of a beneficiary case from the Housing Funds.

3.1.4 Chapter 6: Protecting and promoting human health

The Assadia School's Health point

Providing social services is one of the main objectives of the Old City Rehabilitation, it intends to provide social services to keep the inhabitants in place. Therefore; the emphasis has been put on the development of the social infrastructure in the Action Areas (AA's). In AA1, no health service was available for the neighborhood; after the survey and the participation process, the residents demanded a health point. So a house, which belonged to the Awqaf (the religious endowment), had been identified and renovated by the Project to set a health point in it, in cooperation with the Directorate of Health. This point has ensured the basic health services for the population of this neighborhood.

3.1.5 chapter 7: Promoting sustainable human settlement development

Future Land Use Plan

The general Land Use plan for the Old City of Aleppo has for objective to preserve the residential use and secure housing in the same direction develop mixed uses like commerce and tourism as they help keeping the Old City viable, as well as to preserve the Souk functions and improve recreational activities. The functions are subdivided into specified zones of activities. The future land use plan was set in a way to render the Old City as diversified as possible to keep it viable and sustainable.

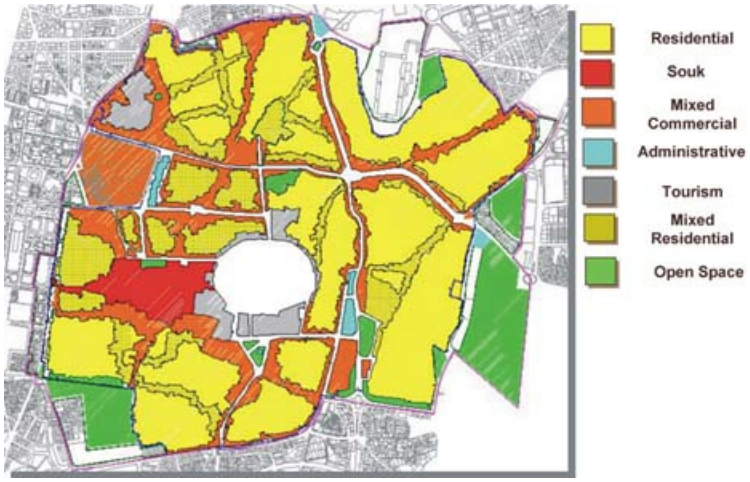

Figure 1 Future Land Use plan for the Old City of Aleppo.

Urban planning oriented towards ecological objectives: the environmental strategy of the Old City:

A strategy was delineated to handle the degraded environment from which the Old City of Aleppo suffer, the defined scope include present and future interventions. The work comprised fixing objectives, strategies and analysing the urban problems for the following topics: legislative framework, air and noise pollution, greening program, water and soil pollution, energy use in buildings and solid waste.

Sustainable Land-use: Noise map on GIS

The intention of this project is to tackle the noise problem and to ensure improvement of living conditions and development of economic viability and sustainability. The noise level are collected using field measurements then placed on a thematic map using the GIS. Availability of spatial analysis tools enable the overlapping of many thematic layers such as (demographic layer to have the ratio of the residents in dangerous areas), and hence to help defining areas where the inhabitants are exposed to excessive levels of noise. Representing this phenomenon clearly can aid the decision makers to focus their attention on priority areas and to model and simulate noise levels based on anticipated changes in conditions.

3.1.6 chapter 9: Protection of the atmosphere

Environmentally compatible transport systems

The Old City of Aleppo is suffering considerably form air pollution, which is an important issue to be tackled due to its intersections with other sectors of activities. Emphasize will be put on a future objective to have a “Clean air from Old Aleppo”. One of the objectives in the field of transport is to introduce environmentally friendly service vehicles such as the small electric cargo cars for the old Souks, which is under discussion with the French Agency for Energy Management (ADEME).

Low energy Buildings

This is a planned project which has a concept to improve the building’s performance in terms of energy consumption and to reduce pollutants’ emissions. This will contribute to an efficient use of energy by setting standards for energy saving and the use of environmentally friendly materials. Promoting the use of renewable sources of energy, like solar energy, will be a target in this field. Although, solar energy is not used, there are numerous possibilities for the installation of solar collectors for water and space heating. Furthermore, the work will

incorporate the elaboration of environmental indicators to set future policy of regulations. These indicators can include energy efficiency indicators, pollution rates and noise levels.

3.1.7 chapter 18: Protection of the quality and supply of fresh water resources

Modernization of infrastructures

The project's objective is to provide fresh water and to prevent water pollution caused by the old sewer system and the unauthorized slaughterhouses. This affects ground water, public health and cause damage to the sewer system by throwing the organic refuse into it. The modernization of the sewerage system will contribute to the upgrading of environmental conditions, the control of water pollution, and the improvements in drinkable water. However, the main strategy should be oriented to increase the awareness of people in this field.



Photo 2 Renovation of infrastructure in the Old City alleys.

3.1.8 chapter 30: Strengthening the role of business and industry

Tourist Trails in Action Areas

The objective of this project is to make the Old City attractive, of course for tourists but also for the inhabitants of Aleppo. To support tourism in the Old City, tourist trails has been developed to link Action Areas with the flow of tourists by preparing trails with maps and sings plus tourist services. Most of tourism revenue in Old Aleppo is concentrated around the famous historic monuments (the Citadel and Souks). So to distribute these revenues ,on a larger scale, and to reorientate the flow of tourists to limit negative impact, tourist trail has been defined, in accordance with the Land Use concept, to support the tourism industry in the Old City.

3.1.9 chapter 36: Promoting education, public awareness and training

Awareness raising campaigns

The Rehabilitation Project has carried out several campaigns in order to raise population awareness towards certain problems like the Cleanness and the Noise campaigns. The Cleanness campaign had for objective to raise the awareness of inhabitants about the importance to have a clean neighborhood to diminish pollution, to ensure the collaboration between them and the Municipality and to develop a sustainable mechanism to face the waste problem in the future. Whereas the Noise campaign was set to highlight a neglected noise problem and to demonstrate its bad effects. The Noise Campaign aimed to discuss the problem with relevant groups to share in promoting the objective of the campaign and adept suitable procedures. Both campaigns had been initiated after a participation process with the

inhabitants themselves in order to assess their needs and oriented to communicate with the target groups in coordination with relevant bodies and institutions.

4. CONCLUSION

New issues had been raised by the unprecedented growth in urban areas which gives concerns to subjects such as, the economy of the City, the social exclusion, the preservation of our natural built environment, the quality of life, the pressure on our natural resources and the negative impact on health. Consensus about future vision, programs and activities as well as the involvement of new type of partnerships and public participation could be reached under the umbrella of the Local Agenda 21 to stop the global deterioration of the environment and guarantee the sustainable use of natural resources.

The Local Agenda 21 of Old Aleppo's action program will permit to reach to a comprehensive analysis of problems, will contribute to develop a future vision and will orientate the formulation of objectives and indicators. It will also help initiating future projects and activities, which will be carried out by the City of Aleppo to promote sustainable development. Finally, the City of Aleppo should allocate money to the Agenda 21 activities to foresee its development, the lack of resources constitutes one of the biggest obstacles to the implementation of the Local Agenda 21. Consequently, we do not want our action plan to be end as a mere bureaucratic paper.

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Exergy needs for winter ventilation in buildings

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ABSTRACT
A brief overview is presented of energy and exergy balances for sensible heat flows (transmission and ventilation) in a basic building space. The building shell is well insulated (U=0.25 W/m^2 K); ventilation is provided at 1.5 air changes per hour, based on gross volume. Since internal and solar heat gains are neglected, it is assumed that all the thermal energy *Q* and exergy *Ex* needed to compensate for transmission and ventilation heat flows is provided by an electrically driven heat pump. The tradeoff between low-grade thermal energy savings and electricity use is investigated for air-to-air heat recovery in winter. Since building ventilation systems operate close to ambient temperature, variations in exergy flows with regard to outdoor temperature are also considered. The results show that, although efficient from an energy viewpoint, the use of electricity to recover and deliver low-grade heat is inefficient in terms of exergy.

1. INTRODUCTION

In colder climates, improvements in building shell insulation and air-tightness imply a shift in heating loads from transmission and infiltration towards ventilation. Air to air heat recovery systems are increasingly being used to minimize ventilation energy needs, while safeguarding thermal comfort and indoor air quality. Many heat recovery systems for HVAC applications consume additional electricity in order to recover low-grade heat. This paper analyzes the effectiveness of heat recovery from ventilation air of a building space from the viewpoint of exergy. The results show that, although efficient from an energy viewpoint, the use of electricity to recover and deliver low-grade heat is inefficient in terms of exergy.

1.1 Exergy as a work potential

Exergy (*Ex*), also known as available energy, can be defined as the work potential of a system (or of natural resources) in relation to the surrounding environment. It is a measure of the departure of the state of a system from that of its environment, [5], [8], [9]. Such a state can be characterized by properties such as temperature or pressure. For example, high-temperature, high-pressure steam can produce more work (e.g., drive a turbine) than warm water, which may be able to heat a room but not to generate electricity. Hence, even if one assumes the same heat content *Q* for (a small amount of) steam and (a large amount of) warm water, the exergy factor (*Ex/Q*) of steam will be higher. For electricity, however, the exergy content is the same as the energy content, since this content can be fully converted into work.

Exergy is not conserved, but is irreversibly destroyed while sustaining any real process [6],[8]. The value assigned to exergy depends on the proper selection of the environment (also called the "dead state" of a substance or system). Exergy analysis provides a means for pinpointing the locations within a system where exergy is degraded. Such degradation, caused by exergy consumption by the system (or exergy losses in its effluents), reduces the "resource value" of the substance or energy carrier used to drive or change the system, [8]. The exergy concept is useful for analyzing systems in which different energy concepts are involved, such

as heat and electricity; it provides a common basis for comparative evaluation, in terms of both quantity and quality.

2. EXERGY AND ENERGY TRANSFER AS HEAT

The thermal exergy required by an indoor space to compensate for outward flows due to transmission E_{trns} and ventilation E_{vent} is:

$$Ex = Ex_{trns} + Ex_{vent} \qquad eq.\ 1$$

2.1 Exergy use owing to heat transmission through the building shell.

The thermal exergy E_{trns} transferred through a building shell (surface area A, overall heat transfer coefficient U) to or from a space at a constant indoor temperature T_{ind}, owing to a temperature difference with an outdoor environment at T_{outd}, can be expressed as:

$$Ex_{trns} = Q_{trns} \times \left| \frac{T_{ind} - T_{outd}}{T_{ind}} \right| = \frac{U \times A \times (T_{ind} - T_{outd})^2}{T_{ind}} \qquad eq.\ 2$$

When internal heat generation and external heat gains are not considered, this outward transfer of heat Q_{trns} and thermal exergy E_{trns} requires the input of corresponding amounts of heat and exergy in order to keep the indoor temperature constant.

The exergy factor E_{trns}/ Q_{trns}, expressed as $|(T_{ind}–T_{outd})/T_{ind}|$, is equivalent to the Carnot factor. The indoor air temperature T_{ind} is presumed to be constant and uniform throughout the room, and temperature differences are assumed to be small enough to justify calculation with an overall heat transfer coefficient. The air is regarded as a dry, ideal gas with specific heat 1.0 kJ/kg K and density 1.2 kg/m^3 at near-environmental temperature, [5], [8].

2.2 Exergy use owing to outdoor air supply.

The exergy transfer E_{vent} accompanying heat transfer Q_{vent} to or from a steady mass flow ($\dot{m}$) of ventilation air (isobaric specific heat c_p) can be stated in simplified form as, [7]:

$$Ex_{vent} = Q_{vent} \times (1 - \frac{T_{outd}}{T_{ind} - T_{outd}} \times \ln \frac{T_{ind}}{T_{outd}}) = \dot{m} \times c_p \times \left| T_{ind} - T_{outd} - T_{outd} \times \ln \frac{T_{ind}}{T_{outd}} \right| \qquad eq.\ 3$$

When sensible heat is recovered by a heat exchanger (heat transfer effectiveness ε), supply air temperature rises from T_{outd} to T_{supl}. The exergy needed to compensate for air supply becomes:

$$Ex_{vent} = Q_{vent} \times (1-\varepsilon) \times (1 - \frac{T_{outd}}{T_{ind} - T_{Supl}} \times \ln \frac{T_{ind}}{T_{Supl}}) = \dot{m} \times c_p \times (1-\varepsilon) \times \left| T_{ind} - T_{Supl} - T_{outd} \times \ln \frac{T_{ind}}{T_{Supl}} \right| \qquad eq.\ 4$$

2.3 Exergy losses related to heat supply and heat recovery.

Assuming heat is supplied by a heat pump, it can be shown [2] that the exergy actually required by the heat pump as electric power (W_{hp}) exceeds the room thermal exergy needs Ex (eq. 1) by losses due to: mix of cooler air with warmer air (Δ_{mix}); heat pump cycle inefficiencies (Δ_{cycle}) upon compression and expansion; temperature differences leading to heat transfer from outdoor air to evaporator (Δ_{eva}) and from condenser to indoor air (Δ_{cond}).

$$Ex + \Delta_{mix} + \Delta_{cycle} + \Delta_{cond} + \Delta_{eva} = W_{hp} \qquad eq.\ 5$$

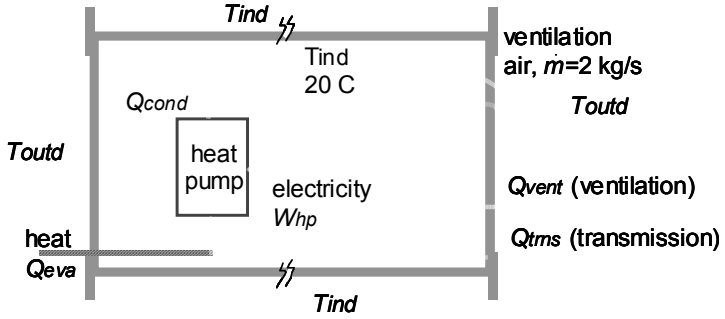
With sensible heat recovery, the need for thermal exergy Ex is reduced, and thereby the electricity supply to the heat pump. On the other hand, electricity requirements are compounded by the need for extra fan power W_{fan} to compensate for pressure drops at the heat exchanger.

2.4 The influence of outdoor temperature

In processes involving exergy flows at near-environmental temperature, exergy flows become relatively sensitive to variations in the environmental temperature, [7]. In this paper, exergy flows are considered for constant indoor temperature T_{ind}=20ºC, and outdoor air temperatures T_{outd} between –20ºC and 10ºC.

3. EXAMPLE FOR A BASIC BUILDING SPACE

The basic energy and exergy balances presented in section 2 are applied to a simple building space. Ventilation is provided at 1.5 air changes per hour based on gross volume. Building shell insulation, outdoor temperatures and ventilation mode (with and without sensible heat recovery) are varied, as shown in Figure 1 (T_{outd}, T_{ind} =outdoor, indoor air temperatures; $\dot{m}$ = mass flow rate; A = wall surface area; U = overall heat transfer coefficient; ε = heat exchanger sensible heat transfer effectiveness). Since internal and solar heat gains are neglected, it is assumed that all the thermal energy Q and exergy Ex needed to compensate for transmission and ventilation heat flows is provided by an electrically driven heat pump.



parameters	values			
T_{outd}[ºC]	-20	-10	0	10
T_{ind}[ºC]	20			
$\dot{m}$ [kg/s]	2			
A [m^2]	500			
U [W/m^{2}K]	0.25		1.00	4.00
ε [–]	0	0.75	--	

Figure 1 Schematic of the building space (left) and main parameter values (right)

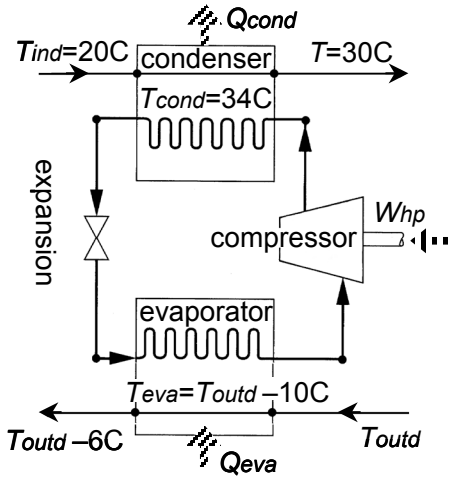




Figure 2 Schematic of the heat pump (left) and sensible heat exchanger (right)

4. RESULTS AND DISCUSSION

4.1 Exergy needs to compensate for heat transmission

Table 1 shows the energy and exergy needed to compensate for heat transmission through the building shell (eq. 2). Due to the relatively minor temperature differences between indoor (T_{ind}=20ºC) and outdoor (T_{outd}) air temperatures, only a small fraction of this heat consists of

exergy. As T_{outd} rises and approaches T_{ind}, exergy needs to compensate for heat transmission decrease much more sharply than the corresponding energy needs. These low exergy values show that what is being lost to the outdoor environment is in fact very low-grade heat.

Table 1: Energy and exergy use to compensate for heat transmission [kW]

			energy needs Q_{trns} [kW]				*exergy needs E_{xtrns} [kW]*			
U_{shell} [W/m^2K]	UxA [W/K]	T_{outd}	*-20ºC*	*-10ºC*	*0ºC*	*10ºC*	*-20ºC*	*-10ºC*	*0ºC*	*10ºC*
0.25	125		5	3.75	2.5	1.25	0.68	0.38	0.17	0.04
1.00	500		20	15	10	5	2.73	1.54	0.68	0.17
4.00	2000		80	60	40	20	10.92	6.14	2.73	0.68

Wall surface area A= 500 m^2; indoor air temperature T_{ind}= 20ºC

4.2 Exergy needs to compensate for outdoor air supply

Table 2 shows energy and exergy needs (eq. 3,eq. 4) to compensate for heat flows resulting from outdoor air supply for ventilation, both without and with sensible heat recovery (heat transfer effectiveness ε =0.75; supply temperatures T_{supl} from heat and mass balances [6]). Although sensible heat recovery reduces energy needs by 75%, it only cuts down exergy needs by 57%.

Electricity input W_{fan} to compensate for heat exchanger pressure drop is taken as 0.9 kW, assuming 350 Pa pressure drop, for supply and return air plus filter, [4]. W_{fan} has relatively little effect on energy needs, particularly for outdoor temperatures T_{outd} lower than 0ºC. In absolute terms, exergy needs are found to be lower with sensible heat recovery. In relative terms, however, the additional electricity input W_{fan} is significant, particularly as T_{outd} increases. For T_{outd} = –20ºC, the additional 0.9 kW required for the fan (W_{fan}) is only 37% of the 2.4 kW thermal exergy Ex_{vent} required to compensate for air supply at T_{suppl}=10ºC. For T_{outd}=10ºC (T_{suppl}=17.5ºC) however, W_{fan} at 0.9 kW becomes 600% of Ex_{vent} at 0.15 kW.

Table 2: Energy and exergy associated with ventilation (heat and electricity) [kW]

no heat recovery	*energy needs Q_{vent} [kW]*				*exergy needs Ex_{vent} [kW]*			
$T_{supl} = T_{outd}$	*-20ºC*	*-10ºC*	*0ºC*	*10ºC*	*-20ºC*	*-10ºC*	*0ºC*	*10ºC*
Q_{vent}, Ex_{vent} *for* ε=0	80	60	40	20	5.7	3.2	1.4	0.35

with heat recovery	*energy Q_{vent}, W_{fan} [kW]*				*exergy Ex_{vent}, W_{fan} [kW]*			
T_{outd}	*-20ºC*	*-10ºC*	*0ºC*	*10ºC*	*-20ºC*	*-10ºC*	*0ºC*	*10ºC*
T_{supl}	*10ºC*	*12.5ºC*	*15ºC*	*17.5ºC*	*10ºC*	*12.5ºC*	*15ºC*	*17.5ºC*
Q_{vent}, Ex_{vent}, ε=0.75	20	15	10	5	2.4	1.4	0.6	0.15
electricity in, W_{fan}	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Volume air flow rate V= 6000 m^3/h (m=2 kg/s), indoor volume=4000 m^3, indoor air temperature T_{ind} = 20ºC

4.3 Exergy losses related to heat supply and heat recovery

It is assumed that all the thermal exergy *Ex* needed to compensate for outward flows due to transmission E_{trns} and ventilation E_{vent} is supplied by a heat pump: no account is taken of internal and external heat gains from e.g. occupants, equipment and solar radiation.

4.3.1 Basic heat pump cycle. A basic heat pump cycle using refrigerant R22 is assumed (no superheating or subcooling, 80% isentropic efficiency). The evaporator (temperature T_{eva} = T_{outd} – 10ºC) receives heat from a stream of outdoor air, which cools down from T_{outd} to T_{outd} –

6ºC. The condenser (temperature $T_{cond} = T_{ind} + 14$ºC) gives off heat to a stream of indoor air. This stream heats up from T_{ind}=20ºC to 30ºC and is mixed with air in the building space to compensate for transmission and ventilation heat losses. The heat pump performance for this basic cycle was estimated based on R22 refrigerant property data [3],[5], for T_{ind} constant at 20ºC and T_{outd} between –10ºC and 10ºC. The *COP* values ($COP=Q_{cond}/W_{hp}$, *see* Figure 2) correspond to ca. 70% of the *Carnot COP* ($\eta Carnot=T_{cond}/(T_{cond}-T_{eva})$). Heat pump *COP* is assumed to be independent of machine size and heating capacity.

4.3.2 Heat pump exergy losses. Exergy needs and losses are shown in (Figure 3 for the building space – well insulated building shell (U=0.25W/m^{2}K); T_{ind}=20ºC; T_{outd} between –10ºC and 10ºC – without and with sensible heat recovery (ε=0.75). Room thermal exergy needs ($Ex_{trns}+Ex_{vent}$) are less than 50% of the exergy input W_{hp} required to drive the heat pump. Heat pump cycle losses consume ca. 30% of the electricity input W_{hp}; heat transfer losses at evaporator (Δ_{eva}) and condenser (Δ_{cond}) consume further exergy (24% to 30% of the input W_{hp}, for T_{outd} = –10ºC to T_{outd} = 10ºC). This is in contrast to the relatively high heat pump energy efficiency (*COP* of 4.1, 5.1 and 6.8 for T_{outd} at –10ºC, 0ºC and 10ºC, respectively). Although efficient in terms of energy, a heat pump cycle operating between 10ºC (heat source) and 20ºC (heat sink) incurs relatively high exergy losses, due to the relatively large temperature differences at evaporator ($T_{outd}-T_{eva}$) and condenser ($T_{cond}-T_{ind}$).

4.3.3 Sensible heat recovery. Basic heat and mass balances [1] are based on steady-state sensible heat recovery; no heat transfer between the heat exchanger and its surroundings; no condensation; and no heat gains from cross-leakage, fans or frost control devices.

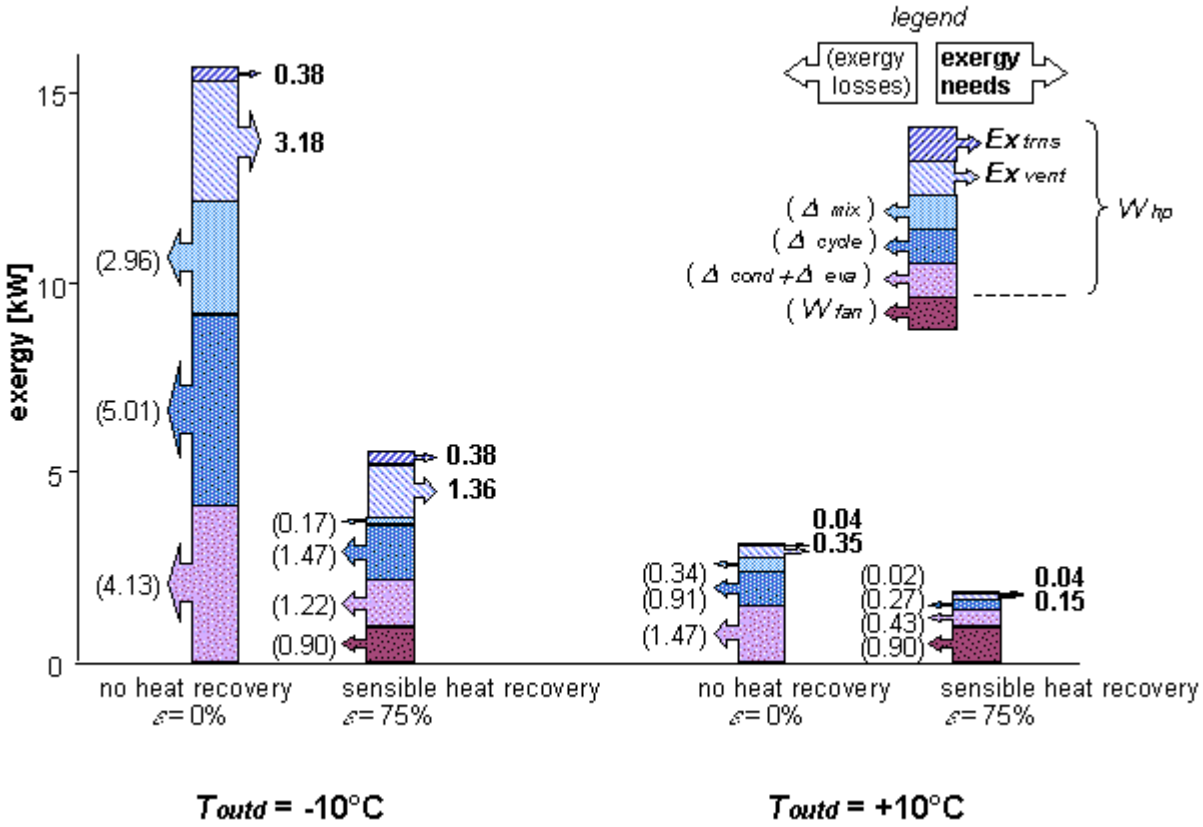


Figure 3 Exergy needs and losses, U=0.25W/m^{2}K, without and with sensible heat recovery (heat exchanger effectiveness ε=0.75)

Sensible heat recovery reduces energy needs to compensate for ventilation Q_{vent} by a factor 4, and the corresponding exergy needs Ex_{vent} by a factor 2. Furthermore, it practically eliminates exergy losses from mixing cold outdoor air with room air. This implies not only a reduction in the total amount of exergy needed to drive the heat pump W_{hp}, but also a relative decrease in the portion of electricity that is consumed by exergy losses (eq. 5). On the other hand, electricity consumption is increased by the additional fan power W_{fan} required to compensate for pressure drops at the heat exchanger and filters. This increase is small for T_{outd}=–10ºC, but becomes significant when T_{outd}=10ºC. For T_{outd}=10ºC, electricity input is 1.8 kW (W_{hp}=0.9 kW; W_{fan}=0.9 kW), and thermal exergy needs are 0.19 kW (Ex_{trns}=0.04 kW; Ex_{vent}=0.15 kW). When T_{outd} is lowered to –10ºC, 5.5 kW of electricity (W_{hp}=4.6 kW; W_{fan}=0.9 kW) are used to deliver 1.75 kW thermal exergy. The ratio of the thermal exergy delivered to the electricity consumed hence triples when T_{outd} is lowered from 10ºC to –10ºC.

5. CONCLUSIONS

This paper presents basic energy and exergy balances for a building space with a well-insulated building shell (A=500 m^2, U=0.25 W/m^{2}K) and 1.5 air changes per hour based on gross volume ($\dot{V}$=6000m3/h ≈ 2kg/s). Indoor temperature T_{ind} is 20C, and outdoor temperature T_{outd} is between –20ºC and 10ºC, with and without sensible heat recovery. Internal and solar heat gains are neglected; it is assumed that all the thermal exergy Ex needed to compensate for transmission and ventilation heat flows is provided by an electrically driven heat pump of relatively high efficiency.

The results show that, although efficient from an energy viewpoint, the use of electricity to recover and deliver low-grade heat is inefficient when evaluated in terms of exergy. This is due to the trade-off between the recovery of low-grade thermal energy and the input of high-grade electric energy. Furthermore, when a heat pump operates with a small temperature difference between heat source (outdoor air) and heat sink (indoor air), heat transfer at the evaporator and condenser becomes a relatively major loss.

Contrary to energy analysis, this basic exergy analysis indicates that the exergy performance of sensible heat recovery and heat pumps are lowered as outdoor air temperatures increase (and hence approach T_{ind}). One may draw the tentative conclusion that, for relatively high outdoor temperatures, passive means (e.g. solar gains, if available and usable) may be more effective than mechanical HVAC systems in providing low-exergy heat for indoor spaces.

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Flexible buildings and cellulose insulation

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1. INTRODUCTION

This paper presents an account of an investigation on the effects of cellulose insulation materials on the cooling loads of a typical office space. The aim is to explore the potential of so-called 'heavy' insulation materials to reduce the cooling load of office buildings with a small thermal mass.
To quantify the effect of using 'heavy' thermal insulation, a dynamical thermal load simulation model (VABI114) was used to simulate conditions in a typical Dutch office space.

1.1 Historical overview

Already in 1919, Canadian homebuilders used untreated, shredded paper as insulation material. In the mid-1940's the industrial production and use of such a material began. Although the patent was deposited already in the 1800's, solid ground for mass production could not be created until 1950 (Siddiqui, 1989).
A Canadian entrepreneur brought cellulose insulation in the 1980's to Germany. His business was bought by a young German wood-craftsman, who saw the potential of the material in the insulation business.

2. RELEVANT CELLULOSE PROPERTIES

Cellulose insulation scores on three mayor themes in environmental strategies:

1 it helps save fossil energy,
2 it helps recycling wasted newspapers, thus saving new forest from being cut and
3 it contributes to a safer and especially sound and healthy indoor climate, if used properly (Ravesloot, 1991).

Cellulose that is fit in a construction by blowing or spraying can last for several decades. The normal density for cellulose insulation is 60 kg/m^3. Certain forms of cellulose, with particularly small grains, have a lower thermal conductivity, under 0,035 W/mK. Technically, these so-called low-mass cellulose insulation materials can not be blown in higher densities than 50 kg/m^3. High mass cellulose, on the other hand, has a bigger grain and can be blown in densities up to 90 kg/m^3 if necessary. The thermal conductivity can then go up to 0,05 W/mK.

These values show that not all applications and not all branches of cellulose insulation can be applied in the conditions assumed for the calculations in this paper. The conditions set for the calculations representing an average of many possible types of cellulose insulation, are shown in the appendix (table 3).

While cellulose insulation is used for winter insulation primarily, during the last two decades owners of houses insulated with cellulose insulation in higher density and in bigger thickness, noticed an improved cooling effect in summer conditions. It seemed that cellulose-insulated wood-framed houses would not overheat as easily as glass wool insulated houses. Thermal mass is likely to play a role in flattening out the dynamics of the outdoor day and night climate.

3. CALCULATION METHOD AND PROCEDURE

3.1 Calculation model (VA114)

VA114 is a dynamic multi zone simulation model for overheating risk assessment which simulates the interaction between building, HVAC installation and environment. VA114 has been tested according to the international BESTEST methods (Judkoff R., et al. 1995). Using hourly climate data such as temperatures, sunlight angles, sunlight intensities and air velocities, the program can simulate one ore more rooms within a building during a specified period.

Some of the input categories within VA114 are: room geometries; physical properties of building materials; physical properties of glazing; internal heat loads (per hour of the day); and HVAC methods and properties.

The output data gives information on: hourly, daily and monthly indoor temperatures; hourly energy use for ventilation, heating and cooling; radiant temperatures; and overheating risk assessment.

3.2 Parameters and input values

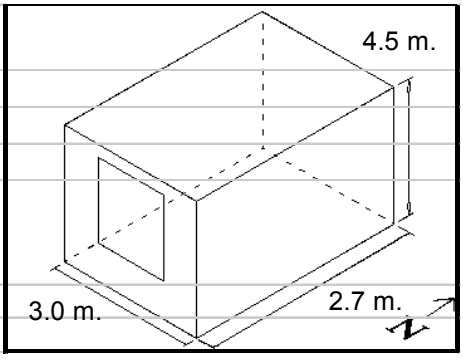
To be able to relate the results to the practice in office buildings, the calculations were made for a typical cell-office in a hot summer day (26/08/1964). Dimensions of the office are shown in Figure 1. The office has one window, oriented to the south.

3.2.1 Baseline conditions. A reference configuration, with baseline conditions, was used for the first calculations. The settings for this reference are summarized in table 1. More detailed information on the conditions assumed for the calculations is shown in the appendix.

Table 1 Summary of conditions

	Baseline case	Alternatives		
Air change rate [h^{-1}]	2	6	8	10
Glass-to-wall ratio [%]	30	60	90	
Sun shading	yes	no		

	Personnel	Computers	Lighting
Internal heat loads [W]	110	150	135



3.2.2 Parameters. Using the reference configuration as a baseline, we evaluated the effect of three parameters: air change rate, glass-to-wall-ratio and sun shading. Table 1 shows the values used in the calculations.

3.2.3 Evaluation Criteria. The results of the calculations were compared using two criteria: the daily temperature amplitude and the damping coefficient.

The temperature amplitude (ΔT) is defined as the difference between the highest and the lowest temperature inside the office during one day.

In order to make a comparison between the temperature amplitudes for three different building materials (glass wool, cellulose and concrete), the damping coefficient (ΔT_{rel}) is used (Oldengarm, 2001). ΔT_{rel} expresses the degree of indoor temperature fluctuation in one single figure. This allows one to position the thermal behavior of the cellulose configuration in relation to concrete and glass wool.

$$\Delta T_{rel} = \left(\Delta T_{glass\ wool} - \Delta T_{cellulose}\right) / \left(\Delta T_{glass\ wool} - \Delta T_{concrete}\right) \quad (1)$$

$\Delta T_{concrete}$ Temperature amplitude: office with exposed **concrete** construction

$\Delta T_{glass\ wool}$ Temperature amplitude: office with light construction and **glass wool** insulation

$\Delta T_{cellulose}$ Temperature amplitude: office with light construction and **cellulose** insulation

The damping coefficient (ΔT_{rel}) expresses a relationship between two reference situations (heavier concrete and lighter glass wool) and a configuration with cellulose. Hence, $\Delta T_{rel} = 0$ implies $\Delta T_{cellulose} = \Delta T_{glass\ wool}$, while $\Delta T_{rel} = 1$ indicates that $\Delta T_{cellulose} = \Delta T_{concrete}$.

4. RESULTS AND DISCUSSION

4.1 Building materials (cellulose, glass wool, concrete)

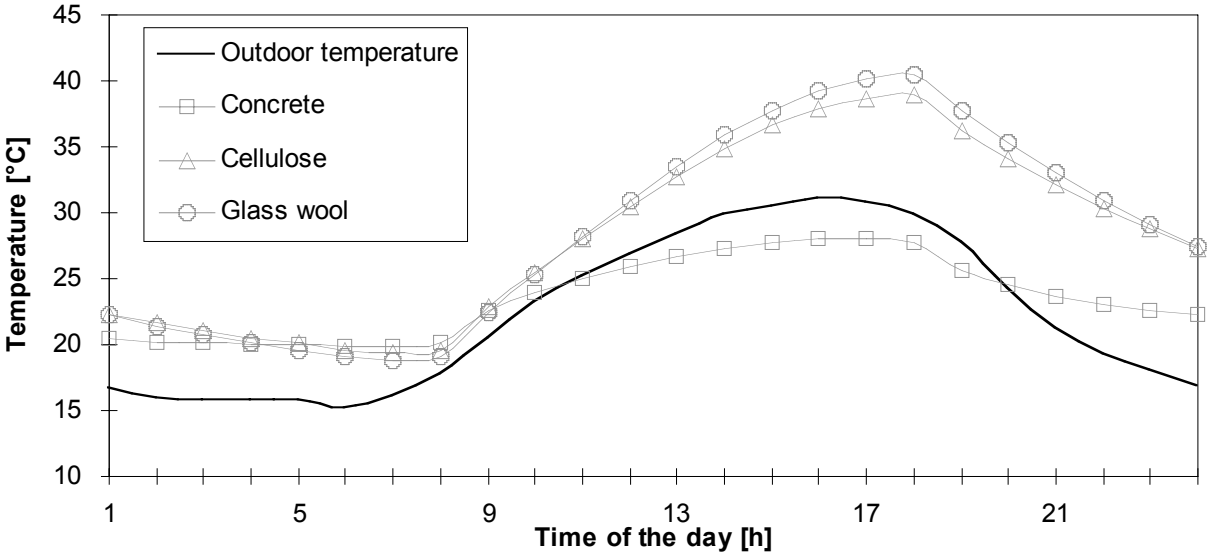


Figure 1 Outdoor and indoor temperatures during a hot summer day

The course of the indoor temperatures during the day is represented in figure 1. The line showing the indoor temperatures of the configuration with a concrete construction is very flat compared to the line of the outdoor temperatures. The lines of both glass wool and cellulose however, show a much bigger amplitude between minimum and maximum.

Figure 2 represents the frequency distribution of indoor temperatures during one season. For every temperature interval the graph shows the number of hours the indoor temperature falls within that interval. If the bars of the graph form a narrow and steep shape, this means the temperature fluctuations are small. If the bars are low and widely scattered over the temperature intervals, the temperature fluctuation is high.

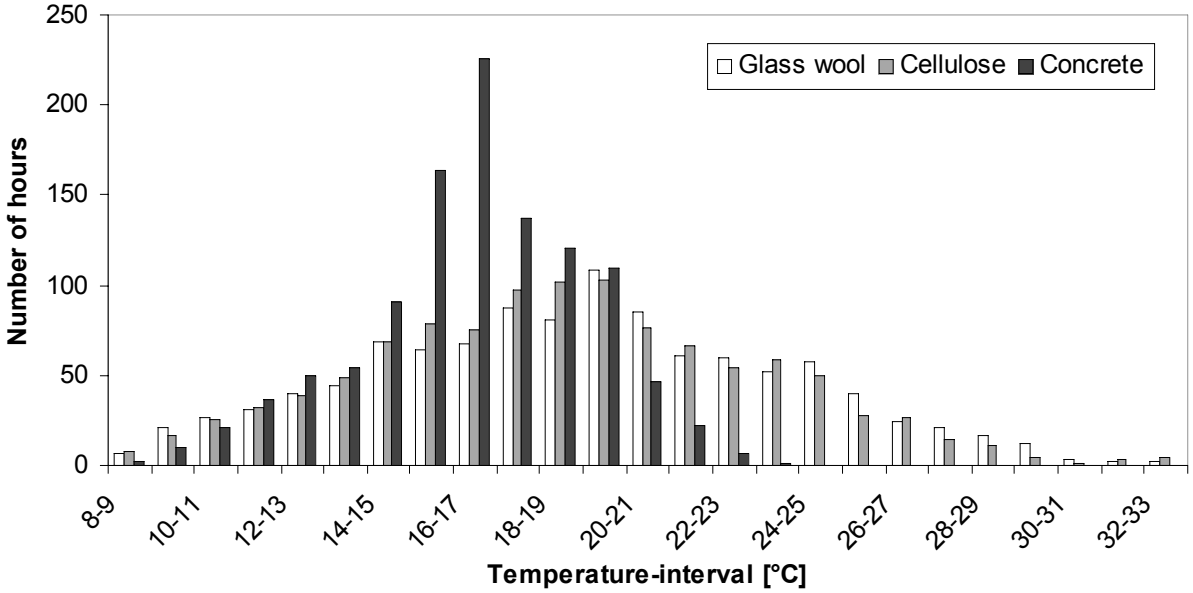


Figure 2 Frequency distribution of indoor temperatures

The figure shows that the temperatures simulated for a glass wool configuration are scattered over a broad range of temperature intervals. The temperatures inside the room with the concrete construction however, are limited to a relatively small number of temperature intervals, which gives the graph a much narrower shape. This narrower shape illustrates how the concrete construction dampens the influence of outdoor conditions on indoor temperatures. The temperatures in the cellulose and glass wool configurations show clear similarities, but in the higher and the mid-range temperatures, the thermal behavior of the cellulose configuration slightly tends towards that of the concrete configuration.

Table 2 Results of calculation for configuration with baseline conditions

	T_{max} [°C]	T_{min} [°C]	ΔT [°C]	ΔT_{rel} [-]
Outdoor temperature	31.0	15.2	15.8	n.a.
Concrete	28.0	19.9	8.1	**1**
Glass wool	40.5	18.8	21.7	**0**
Cellulose	38.9	19.4	19.5	**0.16**

The minimum and maximum temperatures, and the ΔT_{rel} for a hot summer day are listed in table 2. For a cellulose configuration under baseline conditions, a ΔT_{rel} of 0.16 was obtained. Since a glass wool configuration corresponds to a ΔT_{rel} of 0, relative to concrete (ΔT_{rel} =1), these results show that cellulose has a clear advantage over glass wool.

4.2 Ventilation rates

Increasing ventilation rates causes a change in the calculated temperature amplitudes, as shown in the left side of figure 3. The graph clearly illustrates a shift from a building-mass dominated thermal behavior to an outdoor-air dominated thermal behavior with increasing ventilation rates: there is an increase in temperature amplitude for the concrete configuration,

but a decrease for the glass wool and cellulose configurations. The lines of all the indoor temperatures approach the line of the outdoor temperature when the air change rate is increased from 2 to 10 h^{-1}.
The figure shows a decrease in the damping coefficient of the cellulose configuration with higher air change rates. Hence, it can be inferred that the advantage of using cellulose instead of glass wool decreases with an increasing air change rate.

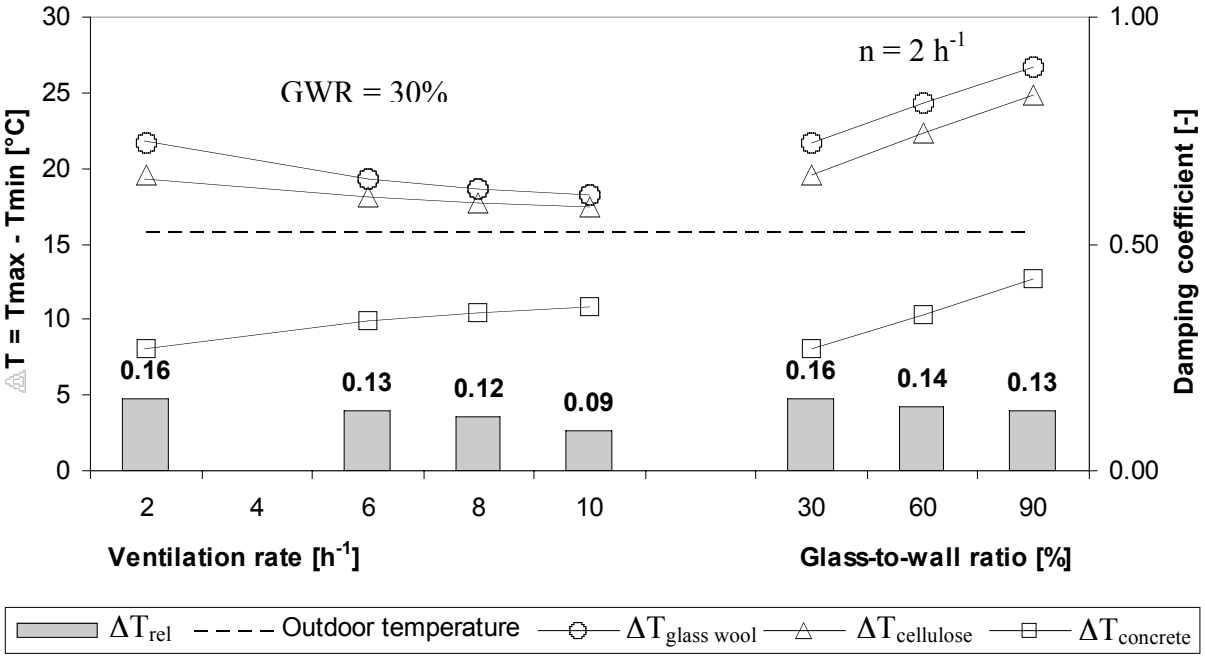


Figure 3 Temperature amplitudes and damping coefficients

4.3 Glass to wall ratio

The right side of figure 3 shows the effect of different glass-to-wall ratios on temperature amplitudes. A higher glass to wall ratio causes higher daily temperature amplitudes, even when the windows are equipped with a sun shading device during the entire day. The effect on the temperature amplitude is substantial. The effect on the damping coefficient, however, is lesser.

4.4 Sunshading

The effect of sunshading was also investigated and found to be quite noticeable in terms of temperature amplitude. However, the effect on the ΔT_{rel} was found to be very small.

5. CONCLUSIONS

When building with a light (flexible) construction, the use of cellulose insulation material yields an advantage of 10 to 20% over glass wool, under the conditions assumed in the calculations. The indoor temperature is dampened by the cellulose material, improving the indoor climate without the use of HVAC installations.

The benefit of using cellulose insulation (expressed as the damping coefficient) was assessed for different conditions of air change rate, glass to wall ratio and sun shading. Variations in these conditions had relatively little effect on the damping coefficient, and hence were not detrimental to the advantage of using cellulose.

The use of cellulose insulation material does not make HVAC installations superfluous, but it can decrease the calculated capacity of these installations, and therefore generate a positive effect upon the environment.

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7. APPENDIX

7.1 Basic calculation conditions

The office has no climatization. Nighttime and daytime ventilation rates are equal.

Table 3 Material properties

	Cellulose	Glass wool	Concrete
Thermal conductivity λ [W/m.K]	0,04	0,04	1,5
Density ρ [kg/m^3]	80	20	2400
Specific heat c [J/kg.K]	1944	799	800
Volumetric specific heat c/V [kJ/(m^3.K)]	155	16	1920

Table 4 Overall heat transfer coefficients [U]

	U [W/m^2.K]
Exterior wall	0.20
Interior walls	1.96
Floors	0.34
Window	2.89

The wall with the window is the only exterior wall. All other walls and floors are interior ones.

In the configuration with cellulose insulation the cellulose layer in the floors is 60 mm thick; on the exterior walls, there are two layers (40 and 140 mm thick).

Environmental Sustainability Assessment of Buildings Using Requirements in Building Energy Codes

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1. INTRODUCTION

In the past decade, building environmental assessment methods have emerged in many parts of the world as a legitimate means to evaluate the performance of buildings across a broad range of environmental issues (Cole, 1999). However, experience to date indicates that the worldwide application of the assessment methods in the building environmental field has met with only moderate success (Chau et al., 2000). There is a need to encourage more participation from building owners and designers and to establish objective assessment criteria for promoting sustainable building practices. These tasks are not only important to developed nations, but are also critical to developing countries striving to achieve sustainable development – which means protecting the environment while pursuing economic growth.

Another major challenge for building environmental assessment is to place building performance within a wider context of environmental sustainability (Cole, 2001). To assess the environmental sustainability of buildings, a number of technological, ecological and socio-cultural factors are involved. The building's energy performance is usually the key element in the evaluation process and will constitute a significant portion of the overall assessment results. With growing interest and importance of building energy codes in many worldwide locations (Janda and Busch, 1994; Hui, 2000), it is possible to make use of the requirements in the building energy codes to support the sustainability assessment of buildings. In order to do that effectively, the nature and characteristics of the codes must be understood and the trends of code development have to be considered.

This study investigates the environmental sustainability of buildings and how its assessment can be enhanced by using the requirements in the building energy codes. By examining some existing building environmental assessment schemes and the development of the building energy codes in the respective locations, it is hoped that better understanding of their interrelationship can be obtained and effective strategy to integrate them can be generated. The experience and prospects in Hong Kong in this area are discussed to illustrate the practical considerations in the design of the strategy.

2. ENVIRONMENTAL SUSTAINABILITY OF BUILDINGS

Sustainability is no longer a luxury to be considered when economic times are good. It is an imperative to be actively pursued with a sense of urgency. Although a large amount of work has been done to document the environmental, economic, and social impacts of the built environment, little has been done to study the effect of building energy codes and the regulatory system.

2.1 Sustainable Performance

In general, the process for assessing performance in achieving environmental sustainability is based on a number of components as shown below.

- Emissions to air
- Greenhouse gas production
- Releases to water
- Contamination of land
- Waste management
- Use of non-renewable resources
- Use of renewable natural resources

However, it is difficult to universally define and quantify the assessment criteria for these components since the local context, global impact and some qualitative factors have to be considered. Extensive research and discussion were being conducted to establish a set of consensus-based sustainability indicators, an objective weighting scale and a framework for the assessment scheme (Cole, 2001). The aim is to operationalise the terms enabling people to assess the environmental impact of their projects from a comprehensive perspective.

In practice, AboulNaga and Elsheshtawy (2001) have presented a case study for hot climates and discussed the importance of having a comprehensive definition of sustainability and clear guidelines for sustainable building practices. They have also illustrated the use of energy data for assessing sustainable building performance.

2.2 Importance of Energy Criteria

The building's energy performance is a key element in the evaluation process. Table 1 shows four examples of assessment methods and their credit points for energy criteria. The energy criteria can constitute 20% to 37% of the total credit points in these examples.

Table 1 Credit points for energy criteria in the assessment methods.

Assessment Methods	Credit Points for Energy Criteria
Building Research Establishment Environmental Assessment Method (BREEAM) 98 for offices, UK (Baldwin et al., 1998)	Max. 120 for total net CO_2 emissions and 88 for other energy criteria. (Total 208 points out of 1,046 available)
BREEAM/Green Leaf for New Buildings, Canada (ECD Energy and Environment Canada, 2000)	100 for meeting/exceeding energy codes and max. 270 for other energy criteria (Total 370 points out of 1,000 available)
Hong Kong Building Environmental Assessment Method (HK-BEAM) Version 1/96R (CET, 1999)	Max. 7 for air conditioning equipment electricity load and 12 for other energy criteria. (Total 19 points out of 59 available)
Leadership in Energy and Environmental Design (LEED) Version 2.0, June 2001 (USGBC, 2001)	Max. 10 for meeting energy consumption criteria, 3 for using renewable energy; 1 for green power. (Total 14 points out of 69 available)

At present, the majority of existing building environmental assessment methods are voluntary in their application and have the primary objective of stimulating market demand for buildings with improved environmental performance (Cole, 1999). When specifying energy criteria, some of them consider and adopt the requirements in the local building energy codes. For example, HK-BEAM makes reference to the Hong Kong building energy codes (Lee, Yik and Burnett, 2001; Yik et al., 1998); LEED refers to ASHRAE 90.1-1999 (ASHRAE, 1999) or the state energy code; and the Canada's BREEAM/Green Leaf requires meeting or exceeding the requirements of ASHRAE 90.1-1999.

3. BUILDING ENERGY CODES

Common strategies for energy regulation and policy include incentive schemes, voluntary standards, mandatory standards and energy labelling (Langston and Ding, 2001). Building energy codes are instruments that guide and specify the direction for improving energy efficiency practices. Legislations can take the form of regulations, guidelines, standards, codes, and others. They may call for voluntary or mandatory actions.

3.1 Major Areas and Compliance Options

Figure 1 shows the major areas and compliance options of building energy codes. The major areas include building envelope, lighting, HVAC (heating, ventilating and air-conditioning), electrical power, lifts & escalators and service water heating. The basic/mandatory requirements are fundamental issues that must be satisfied. The prescriptive requirements, system/component performance and energy budget/cost are the options available for meeting the code's other criteria. For example, prescriptive requirements may be the insulation levels for building envelope components or equipment efficiencies for lighting and HVAC systems. The system/component performance requirements try to combine the consideration of several parameters and provide "trade-off" among them in the compliance process, such as the calculation of overall thermal transmission.

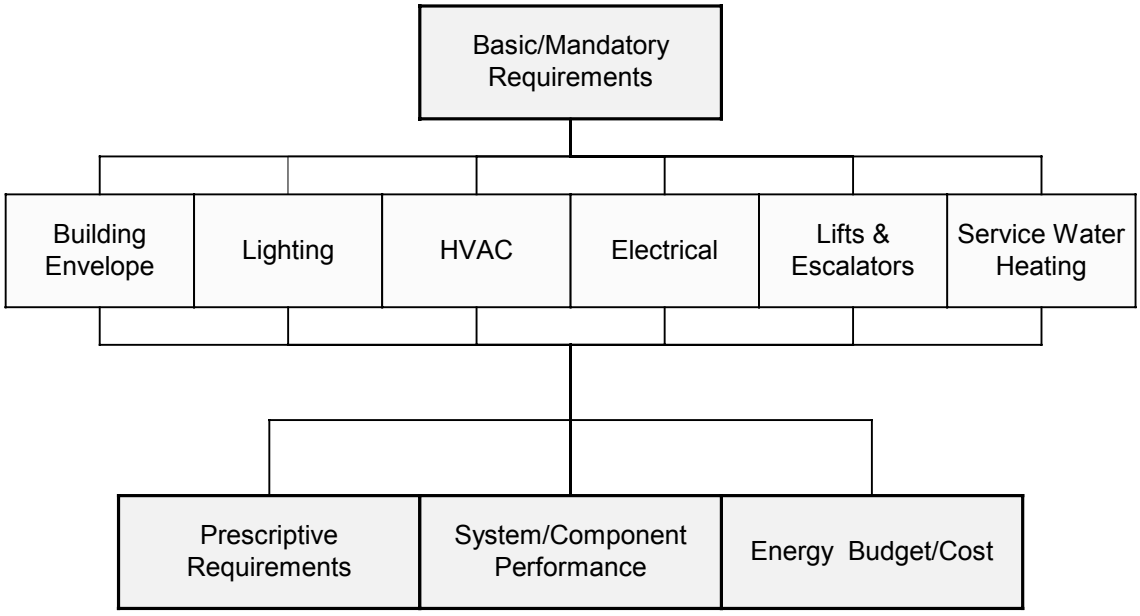

Figure 1 Major areas and compliance options for building energy codes.

The energy budget/cost method offers the greatest flexibility to manipulate the design parameters since it considers in its evaluation the total energy consumption for the building as

a whole. Compliance through the energy budget/cost option will need to study and estimate the likely consumption levels based on the integrated performance of the areas concerned. Since the energy budget/cost method is complicated and demanding, it is usually done by computer simulation and modelling.

3.2 Regulatory Framework

Regulation of energy-efficient building design requires control and guidance at the various stages of design, construction and development. Usually, building energy codes provide a minimum design standard of performance for all buildings to comply. As the procedures for determing compliance with the codes are well established and documented, they can serve as some kind of benchmark for measuring enhanced performance (Hui, 2000). In places where the building energy codes are comprehensive and widely implemented, they can gain wide acceptance as a building energy performance indicator, such as in USA and Canada.

Lee and Yik (2002) pointed out that if the local building energy codes are integrated with the building environmental assessment scheme, building owners will benefit from not having to prepare two detailed sets of information. They also suggested significant energy saving by combining the regulatory and voluntary approaches. However, if the requirements stipulated in the existing codes are mainly prescriptive and not stringent enough, then the design flexibility and actual saving cannot be ensured and optimised. A more holistic approach to the performance evaluation is needed to remove barriers to innovation and to encourage exceeding of marginal compliance. The goal is to influence building practices to become more energy efficient and sustainable.

4. EXPERIENCE AND PROSPECTS IN HONG KONG

As urban development continues to intensify in Hong Kong and as the awareness of sustainable development grows, there is an increasing local concern about the sustainability of the city (Barron and Steinbrecher, 1999). The study of greener and more energy-efficient buildings was also triggered by the quest for better performance and quality in the construction industry. In high density cities like Hong Kong, low energy design of urban environment and buildings requires considerations of a wide range of limiting factors such as land value and building density (Hui, 2001). Future development of building environmental assessment will depend on the establishment of more comprehensive building energy codes and the resolution of other political and economic issues.

4.1 Comprehensive Environmental Performance Assessment Scheme

Hong Kong Government is planning to set up a green building label system as a means of using market force to promote environmentally-friendly buildings. A consultancy study will soon be commissioned to develop this assessment scheme and it is believed the experience of the existing assessment methods will form a useful background. At the same time, review of the building regulations is being conducted with the aim to remove barriers to innovative and green building designs. These initiatives focus not only on new buildings but also on redevelopment of old and dilapidated buildings in the urban renewal process.

An objective and sufficiently demanding measure will be needed to design the new environmental assessment scheme in Hong Kong and to develop relevant performance indicators and benchmarks for charting environmental and sustainability progress. Although it is too early to describe the assessment scheme, it is believed that the following criteria are important for such a scheme.

- Understandable and acceptable by building professionals and general public.
- Practical and cost effective to implement.
- Technically sound and well supported by local research and analyses.
- Clear objectives and good considerations of local conditions.
- Efficient mechanism for implementation, capacity building and market stimulation.

As building environmental assessment is still in the early stages of development and implementation in Hong Kong, a systematic approach is needed to integrate environmental sustainability issues that are meaningful to the society. It is believed that a comprehensive building energy code is useful and important for achieving this purpose.

4.2 Performance-Based Building Energy Code

The existing building energy codes in Hong Kong are prescriptive in nature and they specify for each building component the minimum requirements to satisfy the code, including building envelope, lighting, air conditioning, electrical, and lift & escalator (Hui, 2000). Prescriptive requirements are simple to use, but their effect on the building's energy performance is indirect and this becomes a major barrier to performance optimisation, innovation and technological advancement. To encourage new techniques and greater design flexibility, a performance-based building energy code is now being developed in Hong Kong and a more comprehensive regulatory system will be set up to promote energy efficient designs of green buildings.

The performance approach to building codes emphasizes the practice of thinking and working in terms of ends rather than means (CIB, 1997). The performance-based building energy code will set a maximum allowable energy consumption level without specification of the methods, materials processes to be employed to achieve it. It can be used to allow trade-offs among different aspects of the assessment such that a combination of measures that would yield the best possible performance within the budget constraint can be adopted. Encouragement of innovation is a major reason for using the performance concept (Bröchner, Ang and Fredriksson, 1999). The complexity of the compliance process will need to be resolved through careful code design and suitable capacity building activities. It is believed the new code will form an essential base for designing the energy criteria in the new environmental assessment scheme mentioned before. It will also help to encourage more participation from building owners and designers.

5. CONCLUSION

Like many other urban cities, the buildings in Hong Kong play a significant role in determining the environmental sustainability of the society. Investigation on the existing building environmental assessment methods in the world shows that the energy criteria is a key factor in the evaluation process. To express the assessment criteria unambiguously, a comprehensive definition of sustainability and building energy performance to suit local needs is important. Proper coordination of the requirements in the building energy codes and the environmental assessment scheme is needed.

At present, many of the existing building energy codes in the world are prescriptive in nature. To provide greater design flexibility and encourage innovative design, it is important to move towards performance-based approach and consider the integrated whole building performance in the design and evaluation. To obtain these advantages in the environmental sustainability assessment of buildings, further efforts are needed to integrate the requirements of building

energy codes and the performance concept into the sustainability assessment process. This will help to strengthen the technical base of and confidence with the assessment method.

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Analysis of Visual Grading and Comparison of Strength Properties of Salvaged Lumber to Virgin Lumber

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1. INTRODUCTION

The heightened awareness of environmental concerns and the depletion of our natural resources have caused the construction industry to pursue alternatives to disposal and investigate the reuse of many construction materials. For many decades, the construction industry has favored demolition as the primary means of disposal for buildings that are no longer in service. However, interest in deconstruction has spurred new research and development in many areas. Since many of the buildings constructed decades ago were built of structural lumber, one facet of research has been the reuse of salvaged lumber.

In order for salvaged lumber to be used, substantial research and testing must be conducted in order to minimize the many uncertainties that are inherent in salvaged lumber. This paper reports the results of visual grading and structural tests of salvaged lumber from several residential buildings to provide some data on this issue.

2. SALVAGED LUMBER

The United States is the world's largest producer of waste, generating 260 million tons of waste annually (Kibert et al. 2000). Out of 260 million tons of waste, 136 million tons are a result of construction and demolition waste (C&D). Over 27% of the waste that is generated from C&D is wood waste. If a portion of this can be reused back in the construction industry in place of virgin lumber, it would mean a great reduction in harvesting, transporting, processing, and other energy intensive steps that are used to produce virgin lumber. Reuse of salvaged lumber results in a four-fold benefit: the diversion of waste from landfills, the reduction in the energy use to produce new lumber, the preservation of virgin resources, and the preservation of the invested embodied energy of salvaged lumber.

3. EXPERIMENTAL WORK

Wood Selection

All of the salvaged lumber selected for testing was chosen from deconstructed residential buildings in Gainesville, Florida. The 2x4s originated from a single story, wood-framed house located at 2812 NW 8th Street, built around the 1900s. The 2x6s originated from a single story, wood-framed house located at 2930 NW 6th Street, constructed in 1915. All of wood chosen was southern pine, typical of Gainesville and the surrounding areas. The structural use of the 2x6s was as roof rafters. The primary use of 2x4s was as wall studs.

Visual Grading

Since wood is not a homogenous material, the strength of each piece of lumber will vary depending on its composition. As a result, the American Lumber Standard Committee (ALSC), working with accredited rules-writing agencies, have developed visual grades based on testing and stress grading-principles that are characteristic of each visual grade

(Kretschmann, Green 2000). In order to classify the salvaged lumber, a certified inspector from the Southern Pine Inspection Bureau (SPIB) visually graded the lumber.

Since no standard exists for salvaged lumber, the inspector graded the lumber according to the current standards for virgin lumber. Holes as a result of nails were equated to knots, and other damage was likened to defects in virgin lumber during the grading process. The lumber was graded Select Structural, No. 1, No. 2, No. 3, or No. 4. When many pieces had damaged or split ends, a second visual grade was determined, as if the ends were trimmed. The grade No. 4 was not recognized by the SPIB, but was used to indicate that the specimen had been graded, even though it did not meet the criteria for the lowest visual grade. The primary reason for the No. 4 grade was the presence of insect damage (45%).

Analysis of the data indicated that the prime reason for a lower visual grade for 2x6 rafters was the result of insect damage or twist (81.8%). Of all of the 2x4-salvaged lumber, wane accounted for a lower visual grade in 15 of the pieces (23.8%). The second largest grade-decreasing factor was insect damage, accounting for 14 of the 63 pieces (22.2%). Table 1 shows the results of visual grading.

Table 1 Results of visual grading of salvaged lumber

Grade	Number of 2x6	Number of 2x4
Sel. Str.	10 (29.4%)	13 (20.6%)
1	0	2 (3.2%)
2	11 (32.4%)	10 (15.9%)
3	2 (5.8%)	7 (11.1%)
4	11 (32.4%)	31 (49.2%)
Total	**34**	**63**

Since much of the salvaged lumber possessed damage at their ends, the visual grader provided a second grade, as if the ends were trimmed. In the case of the 2x4s, trimming improved the grade of 24 of the 63 pieces (38.1%). Out of that twenty-four, 20 (83.3%) were graded a No. 2 or better, which have the potential to be used in structural applications. Table 2 shows the effect of the second grade.

Table 2 Effect of Second Grade

1st Grade	2nd Grade	Number
4	Sel. Str.	6
4	2	9
4	3	4
3	Sel. Str.	1
3	1	1
3	2	2
2	1	1
	Total	**24**

Mechanical Testing

Testing of the lumber was performed in accordance with the ASTM D 198 (1994). The purpose of the testing was to evaluate flexural properties of the salvaged lumber. The testing procedure involved applying an increasing load at a constant rate such that the specimen failed in about ten minutes. Shown below in Figure 1 is a representation of the set-up used to conduct the tests. Forty-one 2x4s and sixteen 2x6s were mechanically tested. The effective testing length of specimens fell within the range of 2.2-2.8 meter for 2x4s and 2.5-3.0 meter for 2x6s, and all of them displayed flexural failure. Due to page limitation only the results of 2x6s are reported here (See Treible, 2001 for complete results).

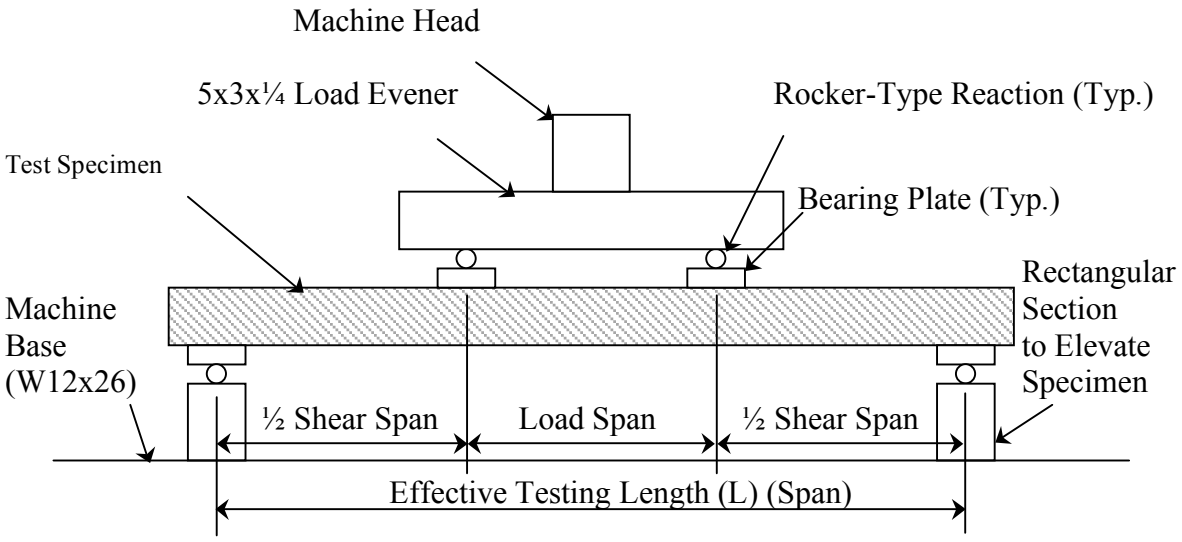

Figure 1 Representation of Testing Set-up

4. TEST RESULTS AND ANALYSIS

National Design Specification Comparison

The first approach to analyze the salvaged lumber properties was to compare them to the design values in the *National Design Specification for Wood Construction-NDS* (AFPA, 1997). The approach to this method was as to convert the ultimate bending strengths and moduli of elasticity of the salvaged lumber to allowable design values (using the adjustment factors outlined in ASTM D 2915 (1993), Table 6) and compare the design values individually to the design values of the same visual grade in the NDS manual.

2x6 Select Structural Salvaged Lumber: Eight samples were tested that met the criteria of select structural. Allowable bending strengths and moduli of elasticity were calculated and are shown in Table 3. The NDS design value for 2x6 select structural was 17.6 MPa. All but one of the 2x6-salvaged lumbers exceeded the NDS design value for virgin lumber. Test sample 61b failed at a relatively low load compared with the other samples because of a large (64 mm dia.) knot near the tension zone (bottom of the beam) and between the load points.

The modulus of elasticity followed an interesting trend in which two distinct groupings were manifested: one group that fell within the range of 10.55 – 10.76 MPa, and another group that fell within the range of 13.51 – 18.75 MPa. This was explained by the specific gravities of the two groupings (Table 3). The lower group had specific gravities that fell within the range of 0.527 – 0.565. The second group fell within the range of 0.606 – 0.680. This analysis showed the direct relationship of the specific gravity to the modulus of elasticity.

The allowable modulus of elasticity is intended to be an average of the applicable species and visual grade. Therefore, a range (a one-tailed confidence interval, in which the lower bound is defined, with range to infinity) is associated with the value given in the NDS manual. According to Appendix F of the NDS manual, the coefficient of variation (CV) for the modulus of elasticity (E) is 25%. Therefore, the lower bound (LB) for the modulus of elasticity would be calculated as (AFPA 1993): LB = E - CV * E

Using this formula, the lower bound of the range would be 9.31 MPa, with the upper bound to infinity. Using this information, all of the 2x6 select structural salvaged lumber would meet the requirement. Taking the group as a whole, the average is 13.79 MPa. Therefore, the average of the group also exceeds the NDS design value of 12.41 MPa.

Table 3 NDS Comparison with 2x6 Select Structural Salvaged Lumber

Marking	Calculated F_b (MPa)	NDS Value F_b (MPa)	Status	Calculated E (GPa)	NDS Value E (GPa)	Specific Gravity
56	32.6	17.6	pass	13.51	12.41	0.606
58	20.8	17.6	pass	10.76	12.41	0.535
61a	37.5	17.6	pass	17.03	12.41	0.680
61b	8.3	17.6	fail	10.76	12.41	0.565
71	28.0	17.6	pass	18.75	12.41	0.661
74	26.6	17.6	pass	10.69	12.41	0.539
78	34.3	17.6	pass	15.31	12.41	0.625
79	21.4	17.6	pass	10.55	12.41	0.527
	26.2	Average F_b		13.79	Average E	

2x6 No. 2 Salvaged Lumber: Seven 2x6s with a visual grade of No. 2 were tested, and the results of the comparison with the NDS design values is shown in Table 4. With a design value of 8.6 MPa for No. 2 grade, all of the test samples passed.

Using the calculated range derived from Appendix F of the NDS manual, the range for modulus of elasticity would be 8.27 MPa – ∞. In this case, six specimens (85.7%) would fall within the range. Test sample 51b would fail, which also sustained the lowest load at failure. Analyzing the average of the group, 11.51 MPa, shows that the average exceeds the NDS design value of 11.03 MPa.

Table 4 NDS Comparison with 2x6 No. 2 Salvaged Lumber

Marking	Calculated F_b (MPa)	NDS Value F_b (MPa)	Status	Calculated E (GPa)	NDS Value E (GPa)
51a	8.8	8.6	pass	8.34	11.03
51b	8.8	8.6	pass	7.52	11.03
54	18.7	8.6	pass	12.68	11.03
59	23.0	8.6	pass	14.55	11.03
62	13.0	8.6	pass	12.27	11.03
68	12.6	8.6	pass	9.86	11.03
75	18.5	8.6	pass	15.24	11.03
	14.8	Average F_b		11.51	Average E

2x6 No. 2 Virgin Lumber

Virgin lumber was also tested to compare the values to the NDS design values. In the testing of seven 2x6 No. 2 pieces, all exceeded the requirement of 8.6 MPa by at least 200% (Table 5). Using the range of 8.27 MPa – ∞ for the modulus of elasticity showed that six (85.7%) would fall within that range. Taking the average of 11.38 MPa showed that, as a whole, the group would meet the NDS design value, but this was only because of the relatively large moduli of elasticity of Nos. 4 and 5.

Table 5 NDS Comparison with 2x6 No. 2 Virgin Lumber

Marking	Calculated F_b (MPa)	NDS Value F_b (MPa)	Status	Calculated E (GPa)	NDS Value E (GPa)
1	27.4	8.6	pass	8.41	11.03
2	23.1	8.6	pass	9.10	11.03
3	21.0	8.6	pass	7.93	11.03
4	30.2	8.6	pass	18.34	11.03
5	38.5	8.6	pass	18.41	11.03
6	27.4	8.6	pass	8.34	11.03
7	24.5	8.6	pass	8.89	11.03
	27.4	Average F_b		11.38	Average E

Comparison of Tested Salvaged and Virgin Lumber

Another method of analysis included the statistical evaluation of the tested salvaged lumber properties to the tested virgin lumber properties. This investigation involved the comparison of the 2x6 No. 2 grade salvaged lumber allowable bending strengths and the average modulus of elasticity to the same grade virgin lumber.

2x6 Allowable Bending Strength: The t-statistic was determined to equal 3.006 with 12 degrees of freedom $(n_1 + n_2 - 2)$. From the Student's t-table, $t_{(05)(12)} = \pm 2.179$. Since the t-value of 3.006 fell outside of the range of ± 2.179, the null hypothesis was rejected with 95% confidence (Figure 2). In other words, there was a statistically significant difference between the averages of the samples. The population was considered highly variable, with the salvaged lumber having a statistically significant lower allowable bending strength than the virgin lumber. An analysis of the confidence intervals of each sample revealed the same conclusion.

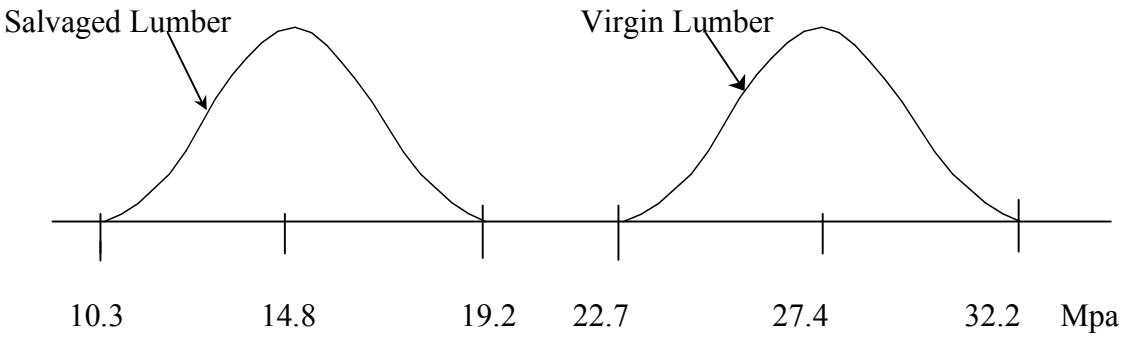

Figure2 Graphical Representation of 2x6 Allowable Bending Strength Comparison

2x6 Modulus of Elasticity: The t-statistic of the modulus of elasticity was determined to equal – 0.045 with 12 degrees of freedom. Since the t-value of – 0.045 fell within the range of ± 2.179, the null hypothesis was accepted with 95% confidence. There was not a statistically significant difference between the moduli of elasticity for the salvaged and virgin 2x6 samples at the 95% level of confidence (11.38 ± 4.00 MPa for virgin lumber and 11.51 ± 1.10 MPa for salvaged lumber).

5. CONCLUSIONS

The results of the visual grading showed that 61.8% of the 2x6s were No. 2 or better. Only 39.7% of the 2x4s were graded as No. 2 or better. However, assuming the ends of the 2x4s were trimmed, this percentage increased to 69.8%. The primary reason for lower grades of No. 3 or No. 4 was the presence of insect damage. When analyzed on an individual basis, the majority of the salvaged lumber bending strengths and moduli of elasticity exceeded the NDS design standards. This may be explained by the relatively denser nature of the salvaged lumber. A statistical comparison of the tested salvaged and virgin lumber showed that the calculated allowable bending strength average of the 2x6s was significantly lower than the virgin lumber, with 95% confidence. The allowable bending strength averages of the 2x4s and the moduli of elasticity of both the 2x4s and 2x6s did not show statistically significant differences, with 95% confidence. Based on these samples, with the exception of the 2x6 bending strength, there is no reason to assume that the salvaged lumber bending strength and modulus of elasticity would be less than these of virgin lumber.

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Heliodons for architects' offices

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INTRODUCTION

Heliodons are commonly used for testing of the directional effect of sunlight on physical building models, aiming at reproducing the actual direction of sunlight impinging onto a building as governed by the variables to be adjusted. These variables are: [2, 3]

- the latitude variable, which defines the sun-paths in relation to the geographical location.
- the seasonal variation, which relates to the declination of the sun on a given day, and
- hourly change of the sun from East to West.

The heliodons developed so far could be broadly categorised into two categories:

- a fixed light source (single lamp or multiple lamps), [2,7,9,10], or a moving light source [1,2], with the building model rotated and/or tilted
- the building model is placed horizontally, and the light source moves [4, 5, 6]

While each heliodon is designed on different emphasis of its purpose of measuring certain variables, and for certain operation convenience, the category with horizontally placed models appear most easily understood to most people including students, professionals, building developers and ultimate building users. A heliodon of this category should be a basic equipment in an architectural office.

In designing a heliodon with horizontally placed building models, there exists a compromise among space available, convenience and speed of operation, ease of understanding of heliodon operation, the dimensions of the heliodon, the dimensions of building model to be tested, its applicability in testing building models of different latitudes, the accuracy of the results offered by the heliodon which primarily depends on the production of quasi-parallel light.

THE ACHIEVEMENTS OF RECENTLY REPORTED HELIODONS DEVELOPED FOR USE IN ARCHITECTS' OFFICE

Heliodons have been developed historically for use in laboratories. In the pursuit of a heliodon suitable for use in an architect's office, with improvement of lighting paralleity by producing quasi-parallel light [i.e. the parallelity aspects of sunlight] to be impinged onto physical building models for simulating various hours of the days and various days of the year, and for varying latitudes, [Fig 1] two table top heliodons have been developed. [12,14, Fig 2, Fig 3].

The one with time rings [14, Fig 2] also shows how the sun moves about the building, effected by the correct movement of the simulated quasi-parallel light. This heliodon, however limits the dimensions of the building models, and limits the models to maximum dimensions of 500 to 600mm cube. Furthermore the horizontally placed models have to be often shifted to catch the light, available at about 500 lux, coming out of , and perpendicular to, the face of the Fresnel lens which is of 220 mm x 220mm.

The one without time rings [12, Fig 3] looks simplest in construction in principle, but unstable mechanically in setting the hours of the days and days of the year. Also it does not explicitly show the movement of the sun around the building model. However the dimensions of the models can go up to 1m cube which is about the norm of most large models built by architects. [15] .For this heliodon, the horizontally placed models have also to be often shifted to catch the light, available at about 500 lux, coming out of, and perpendicular to, the face of the Fresnel lens which is of 220 mm x 220mm.

While horizontally placed models tested in the above two heliodons are normally working models which are loosely, but quickly put together, firmly built models at later design stages can be tested outdoor using direct sunlight as the light source [2, Fig 4] . This is the accurate method for testing building models. But this depends on the availability of sunlight, the altitude angle of sunlight as this correspondingly governs the amount of tilt the model has to be set to, and outdoor suitable environmental conditions such as wind speed and temperature for operators to work through the testing process.

If fact testing building models under the real sun is a long established method by mounting shade dials [8] or traditional sundials on the building model platform. This however involves a non-systematic process of trial and error of tilting the model platform for obtaining the desirable combinations of day and time. While in the light duty heliodon [2, Fig 4], the desirable combinations of day and time are obtained by systematically and conveniently operating the related components and the heliodon, thus effecting accurate and speed testing of the models.

THE PROPOSED BASIC TURNTABLE FRESNEL-LENS HELIODON FOR USE IN ARCHITECTS' OFFICE

Consolidating the advantages and overcoming the disadvantages and limitations of the above two table top heliodons, it is proposed to build a turntable Fresnel-lens heliodon [Fig 5] for use in architects' office for indoor testing of building models.

The key features of this heliodon [Fig 5], are:-

- It can test building models up to 1.2m high, about 2m long and about 1m wide.
- The face area of simulated quasi-parallel light coming from the Fresnel lens is 550 mm x 650 mm, available at about 50 lux, sourced by one 12V quartz-halogen 50W lamp placed at the focal point of the Fresnel lens. 50 lux is acceptable for taking photos with digital cameras.
    - The simulated quasi-parallel light can be set from 0 degree to 90 degree relative to the horizontal model platform, i.e. the altitude angle of simulated quasi-parallel light can range from 0 degree to 90 degree
- The simulated lighting assembly can be adjusted up and down to enable the simulated light to fall onto every part of the models in one, two or three adjustments.

- The horizontal turntable can be easily turned to set the solar azimuth angle relative to the orientation of the building at the desirable combinations of time and day and latitudes, with these combinations easily read off from available solar charts or related software.
- The horizontal turntable and its mounting chassis can slide on an aluminium track relative to the lighting source to enable the simulated light to fall onto every part of the models as the simulated solar altitude angle varies.
- A sundial is mounted onto the model base plate for affirming correct settings of desirable combinations of day and time
    - A solar movement demonstration device is mounted onto the model platform to show solar movement around the building model, corresponding to the solar altitude angle and solar azimuth angle simulated
- This proposed heliodon sits on a movable cart which can be transported to a corner of the office when it is not needed, thus minimizing its storage when it is not being used.
- The building models tested are placed horizontally.

THE PROPOSED COMPLEMENTARY RECOMMENDATION

For testing building models using actual sunlight as the light source as stated earlier, the light duty heliodon is recommended to be enhanced [15] by incorporating strong metal parts to enable it to hold heavier models.

Also the simulated quasi-parallel light of 50 lux coming out of the Fresnel lens of the above proposed basic turntable Fresnel-lens heliodon , or a spot light giving out much stronger light, can be used to test building models indoor with this enhanced metal heliodon, noting that however spot light gives out light which diverge somehow. This divergence will make tests results inaccurate.

CONCLUSION

The proposed basic turntable Fresnel-lens heliodon allows the building models to be kept horizontal. Therefore options of quickly and loosely fitted working models can be tested. This allows quick comparison of options of building models. With the device, mounted onto the model platform, showing solar movement around the building, the architects can communicate much better with the building owners and end users about the tests and solar design of buildings, thus facilitating solar and sustainable design in buildings.

Also this heliodon can be operated in office space of normal dimensions in an architect's office. And the allowable dimensions of building models conform to those normally made by architects.

The above proposed basic turntable Fresnel-lens heliodon, together with the complementing enhanced portable heliodon, should bring about more popular use of heliodons in solar design of buildings.

NOMENCLATURE

AST	Apparent Solar Time, or true solar time.
d	the declination angle of the sun with respect to the centre of the earth, d=+23.44 deg at Summer Solstice and d=-23.44 deg at Winter Solstice. Different declination angles correspond to the different days of the year [Table 1].

L geographical latitude of a place at Northern hemisphere

OQ,OM etc. alphabets with a line underneath mean a line joining the points denoted by the alphabets.

t hour angle, t = 0 deg for solar noon (i.e. AST l2:00 noon), for one hour, the hour angle elapsed is l5 deg., t is positive for AST p.m. and negative for AST a.m.

1,2… component identification numbers of the invented heliodon, shown in the drawings of the heliodon and mentioned in the text

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Figure 1 – see separate drawing enclosed

Figure 2 – The Table Top Heliodon with time rings acting as the track for movement of assembly of simulated quasi-parallel light [from Ref. 14]
Heliodon set for the latitude of Hong Kong [22.5 degree North], noon apparent solar time, Equinox day [21 March or 23 September], with model placed on model platform – looking from the South-West side

Figure 2 is enclosed separately.

Figure 3 – The Table Top Heliodon [from Ref. 12]
Heliodon set for the latitude of Hong Kong [22.5 degree North], noon apparent solar time, Equinox day [21 March or 23 September], with model placed on table

Figure 3 is enclosed separately.

Figure 4 – The Light Duty Heliodon [from Ref. 2]

Building Model for Tokyo (33.75°N) simulated for 4 p.m. AST on 6 June, using direct sunlight in Hong Kong (22.37°N) at 2:35 pm local standard time on 28 Dec 1995. Note that the horizontal plane for placing the model is slanting up towards North in the setting of the equipment, and the reverse side of the plane is used for the other hemisphere.

Figure 4 is enclosed separately.

Sustainable energy use in dwellings. Will the energy use increase with time?

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1. INTRODUCTION

Since the Brundtland Report (Hägerhäll, 1988), also known as Our Common Future, the term *sustainable development* has been widely spread and to develop towards a sustainable energy use is part of this.

The residential, commercial, service sector, etc. stands for a substantial part (approx. 40 %) of the total energy use in Sweden. Since the energy crisis in the 70's there has been a number of energy saving measures carried out in the Swedish housing stock as well as many low-energy housing projects. In a sustainable perspective it is of great importance that the energy use stays on a low level the entire lifetime of the building and not only when it is newly built or reconstructed. In order to fulfil the requirement of low energy use over time the factors influencing the energy use needs to perform well even in a long perspective.

So far few housing projects have been followed up after some years in operation concerning the energy use. Three follow-ups have been found during the search of literature and they show a slight to a substantial increase (5-40 %) in the consumption level after five to ten years in operation (Berggren et al., 1997; Nilson et al., 1997; Weber, 1996). The main hypothesis of the project "Sustainable energy use in dwellings" is that the energy use increases with time in buildings. The aim is to verify this as well as investigating how a possible increase can be prevented. How different parameters, which are affecting the energy use in dwellings, deteriorates over time and which of these parameters that are most significant to changes in the energy use will furthermore be analysed.

The project consists of four phases: a literature study of relevant information, a study of the energy data over time in a number of houses, a theoretical study of how changes influence the energy use, and a field study with measurements of parameters in houses. In this paper parts of the findings of the first phase, the literature study, are presented.

Changes in energy use over time can be due to a number of factors, such as: retrofits and reconstruction made to the building; changed performance of the components, materials or installations of the building; maintenance of the building and its components and installations; or changes in residential habits. In this paper only literature studied concerning the energy performance over time for building components and services is highlighted.

The literature examined refers to, predominantly, Swedish conditions, including Swedish building technique and the Nordic climate. The search of literature has mainly been concentrated to the Swedish libraries, especially the University libraries, reports conducted at SP, the data base "Byggdok" (http://www.byggdok.se/) and reports of the Department of

Building Physics at the Lund Institute of Technology. Additionally, tips on literature have been given by supervisors and colleagues at SP and the Lund Institute of Technology.

2. ENERGY PERFORMANCE OVER TIME FOR BUILDING COMPONENTS AND SERVICES

The total energy use of a building consists of energy for household electricity, heating and hot water production. Building-related parameters influencing the energy used for heating are the transmission losses and air leakages through the building envelope. Approximately 25 % of the heat losses are transmitted through the windows of a dwelling, depending on the orientation of the windows, types of window and the size of the windows. The level of thermal insulation in the building envelope has increased over the years to lower the losses through the walls, roof and floor. The tightness of the building envelope is directly linked to the need of heating, which will increase with increasing air leakage. The tightness is dependent on the performance of gaskets and airtight layers in the construction. A substantial part of the energy used for heating is used to heat the supply air of the ventilation system, which thereafter is exhausted out of the building. The efficiency of the heating and distribution system as well as heat recovery system is also of great importance. A well-performing control system is a prerequisite for a well performing heating and ventilation system in a building.

A sustainable energy use in buildings is dependent on components, materials and installations durability. This means that building components, materials and installations that are significant to the energy use need to keep their performance over time. Bankvall et al. (1986) put forward that there are a lack of research concerning the durability of the components and installations in a building. Eight years later Samuelson (1994) states that the research areas in need of attention are principally unchanged.

In Table 1 the literature concerning the performance over time for parameters influencing the energy use is presented. Note that the number of years that the long-term test or follow-ups regard varies greatly in the different cases.

Table 1 Presentation of literature found concerning the performance over time for parameters influencing the energy use.

Parameter analysed	Method	No. of years	Changes	References
Air tightness				
Air tightness (air changes per hour)	Measurements in 44 single-family houses.	3-10 years	Before: On average 1.02 h^{-1} After: On average 1.29 h^{-1} Slight deterioration. In most houses no considerable change.	(Nilsson et al., 1993)
Performance of EPDM[1] rubber gaskets in joints	Samples tested in laboratory from an experimental house.	14 years	No significant deterioration, although notable changes after 1-4 years. Fulfilled the requirements of a good airtight wall.	(Holmström, 1996)
Performance of	Samples tested in	14 years	No indication of deterioration,	(Holmström,

[1] EPDM stands for ethylene propylene diene monomer and is a rubber material.

LDPE[2] films as air and vapour barrier	laboratory from an experimental house.		although there was a reduction of stabilizer. Fulfilled the requirements of a good airtight wall.	1996; Möller et al., 2001)
Performance of LDPE films as air and vapour barrier	Laboratory tests with LDPE films surrounded by wet concrete.	Not known	Components of the wet concrete accelerate the ageing.	(Jakubowicz et al., 1997)
Ventilation				
Performance of ventilation systems	Evaluation of 5625 compulsory ventilation inspections of ventilation systems in schools, offices and multi-family houses.	Not known	66 % did not pass the inspections.	(Engdahl, 1998)
Performance of ventilation systems	Evaluation of 10 289 compulsory ventilation inspections ventilation systems in multi-family houses, schools, offices and other premises.	Not known	2/3 of the systems did not work sufficient.	(Månsson, 1998)
Performance of ventilation systems	Technical inspections and measurements of ventilation systems in single-family houses (estimated to represent the total housing stock).	No follow up	Approx. 86 % of the single-family houses had ventilation rates below the prescribed rate[3]. On average 0.24 l/m^{2}s.	(Norlén et al., 1993)
Ventilation rates	Measurements in 44 single-family houses.	3-10 years	A reduction on average of 25 %.	(Nilsson et al., 1993)
Exhaust air flows	Measurements in 18 single-family houses.	3-4 years	A decrease in nine houses with more than 10 %.	(Nilsson et al., 1995)
Windows				
Gas leakages	Two accelerating ageing tests of gas filled double-glazing.	Corresponds to 10-20 years	Test one: no significant leakage Test two: 4 % mean reduction	(Christensen, 1983)
Gas leakages	Accelerating ageing tests of gas filled double- or single-glazing with different sealing.	Not known	Double-glazed units with polysulphide had a gas leakage below the requirements. Double-glazed units with other sealing and single-glazed units had gas leakage above requirements[4].	(Knudsen et al., 2000)
Thermal insulation				
Ageing of closed cellular plastic	E.g. the diffusion of the insulating gas was tested in laboratory.	Corresponds to 10 years	Increased thermal conductivity for one insulation material.	(Kokko et al., 1995)
Deformation of	Test of load on insulation	8 000	Deformation increases,	(Bergström,

[2] LDPE stands for low-density polyethylene and is a plastic material.
[3] The prescribed rate is 0.35 l/m^{2}s.
[4] The gas leakage should be less than 1 vol. % per year.

insulation materials (slab on ground)	material in laboratory.	- 20 000 h in laboratory	although not always a clear relationship.	1990)
Settlement of loose fill insulation (attic floors)	Inspections in totally 33 buildings (15 were follow-ups).	5-10 years	Thickness below projected: 11 cases Thickness below settlement allowance: 4 follow-up cases	(Serkitjis, 1997)
Settlement of loose fill insulation (attic floors)	Inspections in a number of houses.	1, 3 and 10 years	After 1 year: 12.7 % After 3 years: 15.4 % After 10 years: 18.5 %	(Svennerstedt, 1998; 1986)
Heat recovery systems				
Performance of heat pumps	Interviews with 100 heat pump owners.	1-9 years	The no. of failures decreased with the no. of years in operation.	(Granryd, 1996)
Performance of exhaust and supply air systems with heat recovery	Follow-up of ten exhaust and supply air systems with heat recovery.	5 years	Exhaust air flow changed on average with –38 %, although great variations. Supply air flow had not changed on average.	(Fahlén et al., 1993)

3. DISCUSSION

In general there seems to be a lack of research in the field of durability and performance over time for a number of building-related parameters as stated by Bankvall et al. (1986) and Samuelson (1994). This especially applies to long-term follow-ups in field.

The airtigtness of the building and parameters affecting it do not show any major detoriation over time. If the development of even more airtight buildings is persistent there might be a need for more knowledge in this field (Isberg et al., 1996).

Although the reports on the evaluations of the compulsory ventilations inspections do not involve single-family houses there are indications of that the ventialtion systems in our houses do not work to our satisfaction. There seems to be a general tendency of a reduction in the air flow during the ventilation system's service period. If the underlying factors are not more thoroughly investigated and the failures taken care of, there might be a risk of an over-dimensioning of the air flow.

There seems to be a gap to fill concerning the ageing of windows. A project on the durability and expected lifetime of energy efficient windows has recently started at SP. A study will be made on how the windows age and if the U-value of the glazing units changes over time. In laboratory tests the gas leakage of insulated windows seem to be related to the type of window and it appears that there are windows on the market that meet the requirements.

Inspections of loose fill insulation materials show that there is a problem with settlement some years after installation. This increases the thermal resistance of the material, subsequently affecting the transmission losses. There are a variety of conditions influencing the settlement and the ageing is important to investigate further in order to be able to compensate with the correct amount of materials needed (Isberg et al., 1996). The gas leakage also affect the performance of insulation materials. The application of the insulation material

affect the problem that occurs, where the deformation due to the load underneath a slab on ground can be mentioned.

The relative short existence of heat pumps and the phasing out of CFC-based working fluids might contribute to the lack of reports on the long-term performances of heat pumps. The long term performance of exhaust and supply air systems with heat recovery seem to have the same problem as ventilation systems without heat recovery, namely too low air flows.

Additionally the long term performance of control systems can be brought up and it can generally be concluded that there seems to be a lack in systematic work in the field of durability and maintenance work regarding control equipments in buildings (Fahlén, 1993).

Regarding the household electricity, no investigations on the long-term performance of white goods or lights have been studied. Most literatures found focus on the replacement of older appliances by newer, more energy efficient, ones. Additionally the efficiency of heat and distribution systems has not been studied.

4. ACKNOWLEDGEMENTS

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Electrochromic Windows as a Chance to Improve Energy Saving in Office Buildings in Mild Climates

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1. INTRODUCTION

Light control systems capable of adjusting both the electric light output and the daylight incoming are recognised to be very important in non-residential buildings, as the artificial lighting is one of the major energy consumers and can influence the HVAC size and the total peak electrical demand. In these last years industries have developed different types of transparent materials and light control systems to improve the design and the operation of non residential buildings to take full advantage of daylight. Specifically, difficulties inherent in producing uniform and stable ElectroChromic (EC) glazing materials appear nowadays to be overcome, so that different double glazed window systems using EC devices coupled are commercially available in different size up to about 2 m^2. Then the possibility to integrate EC transparent materials in building windows, as part of a commercial light control systems, appears nowadays very promising.

Several studies by the LBL group (Lawrence Berkeley Laboratory) report for electrochromic systems in cooling dominated climate the possibility to reach appreciable energy savings respect to more usual windows regardless the type of building; besides they show that control strategies based on making EC darker in function of solar radiation impinging on the external surface of the window can improve both energy savings and indoor comfort (Sullivan *et alt*. 1994, 1996, Karlsson *et alt.* 2000, 2001). Moeck *et alt*. (1998) analyses the use of EC windows to control visual quality, while Yoong and Tulloch (2000) presents some design criteria and utilization of switch-able windows in tropics, that are proved to be until to 30% more energy efficient then the best solar filter glazing systems.

An approach to optimal control settings for linear regulation of EC transparency is presented by Karlsson (2000) for office spaces without taking into account artificial lighting requirementand on the base of typical monthly day outdoor data, loosing, with this last approach, the influence of the stochastic components of meteorological data, that is important in building energy assessment (Gugliermetti *et alt*. 2001/a). The results presented by Gugliermetti and Bisegna (2001/b, 2001/c), which analyse integrated EC control strategies for Italian climate using TMYs (Typical Meteorological Year) and considered artificial lighting consumption, improve Karlsson's approach (2000), but are mainly more oriented to maximise indoor natural illuminance, than energy savings.

This paper analyses, with an integrated approach, visual, thermal and energy aspects connected to the use of EC glazing systems operating as a part of the light control system for office spaces in mild climates. Different window surfaces and EC devices are explicitly investigated in conjunction both with artificial lighting and EC transparency control

strategies, that can be used to keep the space illuminance at the design value when the incoming natural light is not enough. Optimal control settings values for EC device are based on a compromise between reduction in occupants glare, seclusion feelings and energy savings.
Simulations are carried out by the integrated energy analysis program IENUS (Integrated ENergy Use Simulation) developed by F. Gugliermetti *et alt.* (2000/a, 2000/b), that studies hourly thermal and luminous aspects on the base of TMYs. The simulation package was validate against calorimetric and energy consumption measurements performed in office spaces in Mediterranean climate. In IENUS thermal algorithms are based on a transfer function method, while different encapsulated calculation modules allow to simulate the management of the visual and thermal environment

2. CALCULATION HYPOTHESIS

Results are referred to a typical office room with conditioned adjoining spaces kept at the same design temperature. Room dimensions are: floor and ceiling 5x7 m^2, external front and rear walls 5x3 m^2, and lateral walls 7x3 m^2.
The window system is made of several side by side assembled panels of 1.05x2.00 m^2, with a length of the whole window varying from 2.025 m (2 panels) to 4.95 m (5 panels). Each panel is constructed with Al frame and dividers of 75 mm in width, and leaves a free-glassed surface of 0.90x1.85 m^2; the window centre is displaced 1.80 m above the floor and in a central position respect the external wall. The single panel is a double-glazed system made of the EC device and of a clear (EC1) or low-e sputtered multilayer dielectric-metal-dielectric coated (EC4) glazing material. Table 1 reports their broad band visible and solar parameters; specifically, τ_{snh}, τ_{vnh}, r_{snh}, r_{vnh} represent respectively the solar or visible normal hemispherical transparency or reflectance, while ε the infrared emittance. Thermal and optical central characteristics of glazing materials and systems are reported in Table 2 and Table 3, where U_c is the total heat transfer coefficient referred to the centre of the system. Table 4 reports geometrical characteristics and thermal transmittances for each window system; S_w is the total window surface and U the thermal transmittance. Other room and HVAC characteristics are reassumed in Table 5.
A light control system operates in the room; the EC state changes depending on a light-sensor signal, while an electric light control system verifies the natural illumination level at different point of the working plane (at 0.80 m) and dims (3 zones or 1zone dimming) or turns on/off the artificial light to guarantee the design illuminance, fixed at 500 lx (UNI 10380) in the darkest points. Also a on/off or linear EC control strategy is adopted; in the On/off Control Strategy (OCS) the device state is reversed when the solar total irradiation impinging on the external surface of the window is greater than the set-point of the regulator. In the Linear Control Strategy (LCS) the controller requires to fix the set-points a minimum and a maximum values of the total solar radiation to vary EC transparency.

Table 1: EC device characteristics

	Bleached state	*Colored state*
τ_{vnh}	0.508	0.217
r_{vnh}	0.217	0.220
τ_{snh}	0.419	0.159
r_{snh}	0.168	0.174
ε	0.515	0.515

Table 2: Central glazing materials characteristics

	Outer glass		*Mid.*	*Inner glass*	
	Exterior face	Interior face	----	Exterior face	Interior face
EC1	Electrochromic		Air 15.7 mm	Clear 6 mm	
	See Table 1			ε = .840 τ_{snh} = .775 τ_{vnh} = .881 r_{snh} = .054 r_{vnh} = .057	ε = .840 τ_{snh} = .775 τ_{vnh} = .881 r_{snh} = .054 r_{vnh} = .057
EC4	Sputtered multilayer		Air 15.7 mm	Electrochromic	
	ε = .840 τ_{snh} = .243 τ_{vnh} = .403 r_{snh} = .195 r_{vnh} = .122	ε = .110 τ_{snh} = .243 τ_{vnh} = .403 r_{snh} = .238 r_{vnh} = .145		*See Table 1*	

Table 3: Central glazing system characteristics

	EC state	τ_{snh}	τ_{vnh}	U_c *[W/m²K]*
EC1	Bleached	0.329	0.455	2.38
	Colored	0.125	0.195	
EC4	Bleached	0.106	0.211	1.65
	Colored	0.040	0.090	

Table 4: Window systems geometrical characteristics and thermal transmittances

	Length [m]	S_w *[m²]*	*U [W/(m²K)]*	
			EC1	*EC4*
2 panels	2.025	3.330	2.629	2.036
3 panels	3.000	4.995	2.645	2.037
4 panels	3.975	6.660	2.636	2.025
5 panels	4.950	8.325	2.631	2.017

Table 5: HVAC and room characteristics

HVAC			*ROOM*		
People occupancy: everyday 8.00 AM-20.00 PM	3	-	Envelope construction weight	200	kg/m²
People sensible heat (50% convective, 50% radiative)	50	W/p	External wall thermal transmittance	0.8	W/(m²K)
Artificial lighting load: everyday 8.00 AM-20.00 PM	600	W	Ground reflectance	0.2	%
Equipment thermal load: everyday 8.00 AM-20.00 PM	800	W	Internal wall visible reflectance	50	%
Latent loads not considered	-	-	Floor visible reflectance	20	%
Ventilation not considered	-	-	Ceiling visible reflectance	80	%
Infiltration not considered	-	-	Room furnishing: ordinary, no carpets		

3. RESULTS

Different window orientations are analysed for Rome (latitude 42°), that is characterised by a mild Mediterranean climate with an uniform distribution of cold and hot months. The analysis is developed by using setting values of the EC device control that produce indoor acceptable comfort quality, dropping the criteria to reach a minimum energy consumption. An extended

discussion of this criteria, based on discomfort glare from skylight and seclusion feelings, will be not presented in this paper, that is mainly oriented to energy aspects. The criteria to start EC regulation when begins the sky glare (in correspondence of Daylight Discomfort Index DGI =22) and to keep below 20% the percent of the yearly working time in which the EC device is in its colored state points out the following optimal setting values: a) for LCS with EC1 window system 100-600 W/m^2 for South and West and 150 W/m^2 for North orientation, while for EC4 250-800 W/m^2 for South, 250-850 W/m^2 for West, 250 for the North, b) for the OCS with EC1 window system 400 W/m^2 for South, 300 W/m^2 for West and 150 W/m^2 for North orientation, while for EC4 window system 500 W/m^2 for South, 400 W/m^2 for West and 250 W/m^2 for North orientation.

Calculated yearly energy total requirements take into account both the cooling/heating loads and the electric light consumptions and are converted to primary energy source, expressed as equivalent tons (10^3 kg) of petroleum (tep), on the base of the following conversion coefficients: a) Electric cooling system Coefficient of Performance COP=3.2; b) Heating system efficiency η=0.8; c) Artificial lighting system Ballast Factor BF=0.8, with constant efficacy; d) Electric Energy Conversion EEC= 2.5x10^{-4} tep/kWh. The very small energy required to switch EC devices, about 0.08 kWh per m^2 of window every year (Yoong and Tulloch, 2000), is not considered.

Results are presented from Table 6 to Table 10 for several window surfaces. Each Table shows for three of the four main orientations (generally, East and West consumptions are similar) yearly energy total requirements, expressed in tep, and heating, cooling and lighting energy requirement components, expressed in GJ, for both EC control strategies and different complexity of the artificial light control system. Only Table 8 is dedicated to EC4 window system, being competitive with EC1only in critical conditions.

Table 6: 2 panels EC1 window systems: yearly energy requirements

	Artificial Light Control	***LCS***				***OCS***			
		Tep	*Cooling [GJ]*	*Heating [GJ]*	*Light [GJ]*	*Tep*	*Cooling [GJ]*	*Heating [GJ]*	*Light [GJ]*
South	3 dim	0,569	5,39	0,25	5,11	0,569	5,44	0,25	5,11
	No dim	0,971	8,98	0,15	8,89	0,983	9,11	0,15	8,98
North	3 dim	0,747	3,77	0,45	7,49	0,811	4,29	0,40	8,12
	No dim	0,950	5,48	0,32	9,46	0,950	5,48	0,32	9,46
West	3 dim	0,771	5,82	0,29	7,32	0,766	5,63	0,31	7,31
	No dim	0,996	7,77	0,21	9,46	0,993	7,57	0,22	9,46

Table 7: 3 panels EC1 window systems: yearly energy requirements

	Artificial Light Control	***LCS***				***OCS***			
		Tep	*Cooling [GJ]*	*Heating [GJ]*	*Light [GJ]*	*Tep*	*Cooling [GJ]*	*Heating [GJ]*	*Light [GJ]*
South	3 dim	0,458	4,87	0,55	3,85	0,460	4,96	0,55	3,85
	1 dim	0,555	5,72	0,47	4,78	0,553	5,78	0,47	4,75
	No dim	0,912	8,91	0,31	8,16	0,901	8,87	0,32	8,05
North	3 dim	0,643	2,35	1,17	6,39	0,650	2,41	1,18	6,45
	1 dim	0,727	3,03	0,96	7,27	0,732	3,07	0,96	7,31
	No dim	0,946	4,78	0,67	9,46	0,946	4,78	0,67	9,46
West	3 dim	0,678	5,11	0,72	6,27	0,678	4,89	0,77	6,30
	1 dim	0,768	5,83	0,61	7,16	0,762	5,56	0,65	7,15
	No dim	1,005	7,83	0,44	9,46	1,000	7,56	0,47	9,46

Table 8: 3 panels EC4 window systems: yearly energy requirements

	Artificial Light Control	***LCS***				***OCS***			
		Tep	*Cooling [GJ]*	*Heating [GJ]*	*Light [GJ]*	*Tep*	*Cooling [GJ]*	*Heating [GJ]*	*Light [GJ]*
South	3 dim	0,655	6,20	0,25	5,90	0,664	6,28	0,25	5,99
	1 dim	0,749	7,03	0,22	6,79	0,753	7,07	0,22	6,83
	No dim	1,010	9,37	0,17	9,24	0,998	9,25	0,17	9,12
North	3 dim	0,760	3,75	0,49	7,63	0,760	3,75	0,49	7,63
	1 dim	0,813	4,19	0,44	8,15	0,813	4,19	0,44	8,15
	No dim	0,949	5,32	0,37	9,46	0,949	5,32	0,37	9,46
West	3 dim	0,833	6,42	0,30	7,88	0,843	6,46	0,30	7,98
	1 dim	0,880	6,83	0,28	8,33	0,887	6,84	0,28	8,41
	No dim	1,000	7,86	0,24	9,46	0,998	7,80	0,25	9,46

Table 9: 4 panels EC1 window systems: yearly energy requirements

	Artificial Light Control	***LCS***				***OCS***			
		Tep	*Cooling [GJ]*	*Heating [GJ]*	*Light [GJ]*	*Tep*	*Cooling [GJ]*	*Heating [GJ]*	*Light [GJ]*
South	3 dim	0,410	5,06	0,97	3,10	0,414	5,17	0,95	3,12
	No dim	0,821	8,66	0,57	7,08	0,814	8,68	0,58	6,99
North	3 dim	0,573	1,54	2,24	5,38	0,588	1,65	2,20	5,54
	No dim	0,951	4,25	1,17	9,46	0,951	4,25	1,17	9,46
West	3 dim	0,620	4,87	1,42	5,40	0,626	4,65	1,50	5,49
	No dim	1,021	8,05	0,79	9,46	1,015	7,71	0,84	9,46

Table 10: 5 panels EC1 window systems: yearly energy requirements

	Artificial Light Control	***LCS***				***OCS***			
		Tep	*Cooling [GJ]*	*Heating [GJ]*	*Light [GJ]*	*Tep*	*Cooling [GJ]*	*Heating [GJ]*	*Light [GJ]*
South	3 dim	0,397	5,61	1,42	2,64	0,401	5,74	1,39	2,67
	No dim	0,723	8,36	0,97	5,88	0,717	8,45	0,94	5,79
North	3 dim	0,532	1,04	3,49	4,57	0,549	1,14	3,42	4,76
	No dim	0,961	3,84	1,76	9,46	0,961	3,84	1,76	9,46
West	3 dim	0,587	4,92	2,22	4,71	0,600	4,69	2,32	4,88
	No dim	1,030	8,27	1,23	9,34	0,972	7,44	1,35	8,83

Results are of great interest. Considering EC1 window system with LCS and passing from 2 to 5 panels, it is evident that energy requirement sensibly decreases for orientation South, sensibly increases for orientation West, while the North presents a minimum when 3 panels are used. The situation is similar for EC1 with OCS, excepted the case of West and 5 panels, where a decrease of both cooling load and artificial lighting load, in spite of a great increase of heating load, all due to a large window surface and to a scarcely flexible light regulation, causes a sensible decrease of energy requirement. Generally, LCS presents a better behaviour respect to OCS for a 3 zones dimming solution, while a no dimming strategy for artificial lighting presents better results with OCS. This is basically due to the high affinity and compatibility of the best two controlling systems with their high rate of flexibility: more refined is the EC control system, the more refined must be the artificial lighting control to obtain a great energy saving. On the whole, however, minimum primary energy total requirements for LCS and OCS are comparable; the increasing in cooling loads produced by OCS, respect to LCS, is counter balanced by the reduction in the artificial lighting; increasing artificial lighting requirement, by changing either the number of dimming zones or the minimum required illumination, is in favour of LCS when energy savings are considered.

Utilising the EC4 window system, all these considerations are taken to the extremes: North orientation doesn't seem to feel differences between LCS and OCS; South and West instead present always better performances with LCS and 3 zones dimming, and the worse ones with OCS and no dimming.

4. CONCLUSIONS

The work presents a visual, thermal and energy integrated analysis of different EC systems for office spaces in mild climates, specifically in the city of Rome; several natural and artificial lighting control strategies are considered with different window surfaces. The analysis is developed by using "visual" values of EC control parameters to regulate EC transparency, for a good compromise between reduction in occupants glare and seclusion feeling. The paper puts in evidence the importance of the integration of different solutions, that is window surface dimensions, window typology and control systems and strategies to obtain energy saving when varying the orientation of the window. Results are very interesting, as they underline the importance of combining refined control systems to obtain a sensible energy saving. Nevertheless a lot of work still must be done to find an accordance between energy and visual optimal control values, to extend this analysis to a complete (Mediterranean) climate typology.

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Green Globe Design Phase Assessment for Tourism Facilities and Infrastructure

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1. INTRODUCTION

The need for a new tool for assessing the level of sustainability of buildings and built infrastructure has emerged from on going assessment within the tourism and travel industry. The existing Green Globe approach developed in recent years is tailored for the post construction phase of the project. Research work has identified the need to complement this approach with a pre-construction tool to assist prospective owners and design professions meet the needs of Green Globe during design.

The aim of the paper is to describe the theoretical basis for the tool and the basic assumptions of its framework. The approach is based on both relative and absolute assessment system. It uses a selective number of quantitative and a range of qualitative indicators. A strategy mapping technique has been devised to avoid making a prescriptive didactic tool and allowing it to mesh with the creative early design phase process.

In addition a case study is presented where the tool has been tested and the outcomes from the design team identified. The tool is at present entering the discussion phase with industry before role out through a diffusion program.

2. GREENGLOBE 21 STANDARD MECHANISM

2.1 Green Globe 21 Standard Mechanism

Figure 1 illustrates the support mechanism and the participation levels of existing GG 21 standard. A number of support mechanisms that Green Globe deploys are-

- *Key Performance areas:* Nine key performance areas
- *Sustainability Performance Indicators:* Eight Earth check indicators to measure and monitor key performance areas
- *Sustainability Assessment:* Benchmarking against baseline practice with Earth Check Indicators

- *A successful completion of benchmarking and conformity to all the 5 sections to get certified*

The existing Green Globe 21 standard system undergoes three participation levels, Affiliation, Benchmarking and Certification. This A-B-C process has been devised to ensure best practice sustainable tourism operations managed by the registered members.

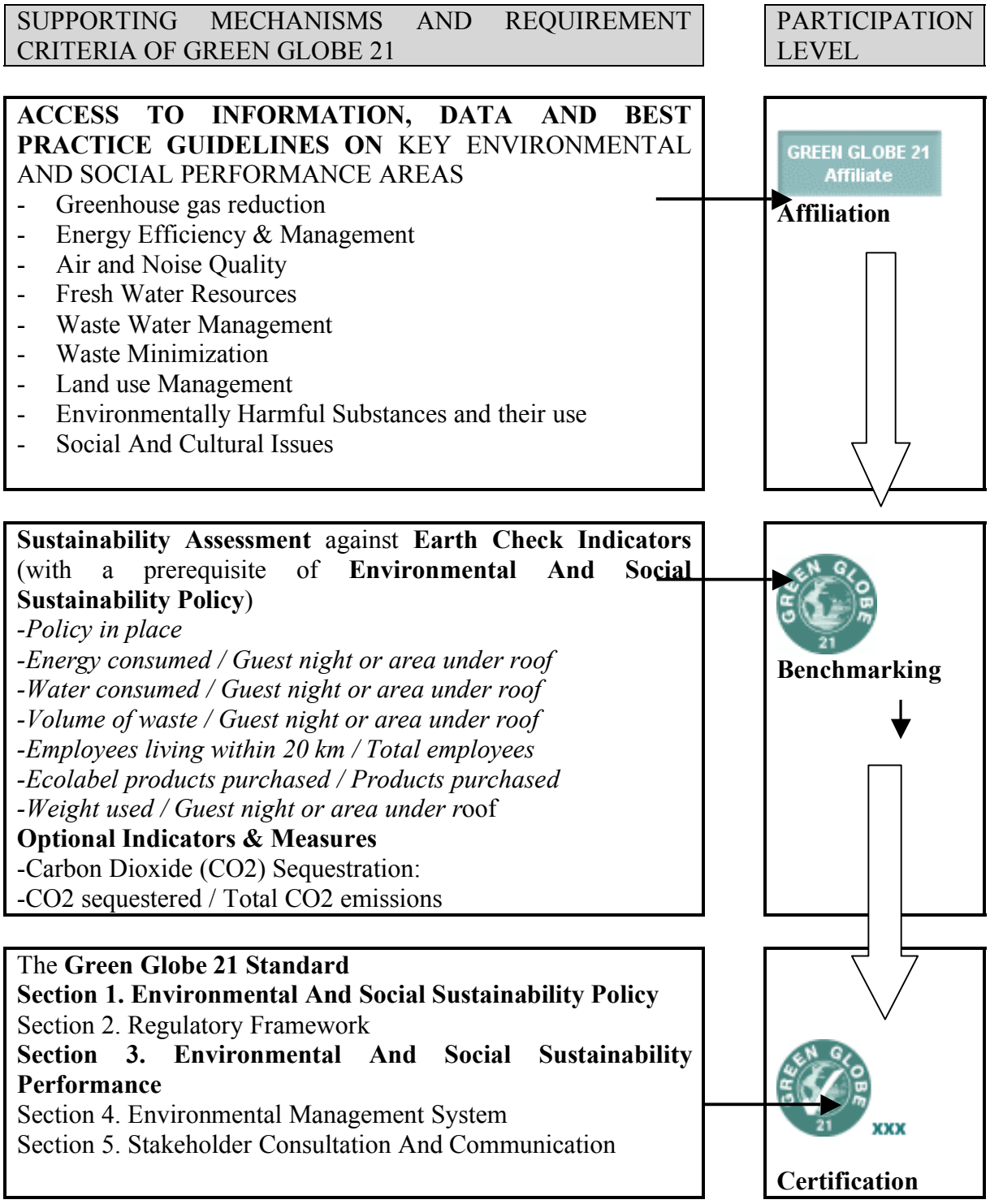

Figure 1: The support mechanism of GG 21 Standard

However the benchmarking stage can be regarded as the core of the whole system as it leads the path to a well-deserved certification and requires encompassing a range of criteria to make it a holistic assessment and relevant to sustainable tourism at the same time. For the development of a Green Globe design phase system, the suitability of a range of criteria was evaluated to provide the appropriate skeleton for a comprehensive mechanism to assess design efforts of best practice sustainable tourism facilities. The considerations being-

- It should encompass the key performance areas established by Green Globe 21 Standard (GG21)
- Provide a framework that tracks indicators corresponding to the earth check indicators defined by GG21
- Should be an extensive process, that can inspire operators to formulate, document and manage their actions and lays a basis for a regulatory environmental management system eventually.
- Easy to follow and well grounded in professional practice for a better response and uptake amongst professionals.

3. DESIGN PHASE ASSESSMENT APPROACH

The research approach involved a review of design phase tools for integrating sustainability issues. The design phase in the context of this research means the period pre-construction, where the basic concept and sketch design of the building is being developed.

This focused first on international systems notably the GBC and LEED systems and on systems in Australia. It is clear that these tools represent both National and International Standards for environmental design and as such some comparison between the scope of these tools and the Green Globe approach should be addressed. In this way the Green Globe systems can be reconciled with the acceptable performance standards world wide. The GBC tool was examined as an example of such a standard.

3.1 Green Building Challenge (GBC)

Resource Consumption
Environmental Loadings
Indoor Environmental Quality
Quality Of Service
Economics
Management
Commuting transport

Table 1: Green Building tool performance issues

Green Building Challenge (GBC) is a consortium of nineteen countries aimed at developing a tool for assessing the level of sustainability in a building. The tool is aimed at providing post construction assessment based on building performance information. The tool is in a stage of development and part of the process is the creation of a second-generation assessment system. The system designed so as to account for the regional differences, contextual settings and other disparities and to carry out the objectives, software called Green Building tool has been developed. GBC tool offers a comprehensive and well-recognized framework that holds great potential for providing the spine for a design phase assessment.

The main categories, which are used in the tool, are shown in Figure 3. These are used to structure a number of building related indicators, which in turn rely on building performance data for assessment.

But before these frameworks can be referred to, there is a need to see whether the chief performance issues are in conformity to the GG 21 standard key performance areas. Table 2 and 4 shows the cross tabulation of the main categories with the Green Globe Standard.

Table 2: Cross linking of GB Tool and GG21 Standard

Key: 'y' similarity between standards

	Green Globe 21 Standard Key Environmental and Social Performance Areas								
GB Tool Performance Criteria	Greenhouse gas reduction	Energy Efficiency & Management	Air and Noise Quality	Fresh Water Resources	Waste Water Management	Waste Minimization	Land use Management	Environmentally Harmful Substances and their use	Social And Cultural Issues
Environmental Sustainability Indicators	y	y		y			y		
Resource Consumption	y	y		y			y		y
Environmental Loadings	y		y		y	y		y	y
Indoor Environmental Quality		y	y					y	y
Quality of Service		y	y	y			y	y	y
Economics									
Pre-Operations Management	y	y	y	y	y	y	y	y	y

Conclusions from this analysis show that there is a similarity between the two systems in the scope of the issues covered. Key areas of difference is in the issues of economics.

3.2 Australian Building Energy Council (ABEC) and Royal Institute of Australian Architects (RAIA) Criteria

A review of the ABEC and RAIA approaches to environmental sustainable development was carried out (ESD was found in the two sources, ABEC has developed a template for developing case studies of mainly energy efficient buildings (www.abec.com.au). The RAIA template is a comprehensive checklist organized around the design inputs and design responses. This is based on the selection criteria used to assess excellence in ESD for award purposes and is endorsed by the building design professionals. The integration of this is seen in Figure 2.

The analysis of the template is useful in producing a good data base but doesn't offer any method to aggregate that data.

Sitinq And Urban Issues
Energy Efficiency And Consumption
Selection Of Building Materials And Process
Protection Of Air, Earth And Water
Construction
Social Issues
Energy Issues

Table 3: ABEC and RAIA criteria

Table 4: Cross linking of ABEC/RAIA template and GG21 Standard

Key: 'y' similarity between standards

	Green Globe 21 Standard Key Environmental and Social Performance Areas								
	Greenhouse gas reduction	Energy Efficiency & Management	Air and Noise Quality	Fresh Water Resources	Waste Water Management	Waste Minimization	Land use Management	Environmentally Harmful Substances and their use	Social And Cultural Issues
Template Criteria									
Siting And Urban Issues			y	y			y		y
Energy Efficiency And Consumption	y	y							
Selection Of Building Materials And Process	y		y			y		y	
Protection Of Air, Earth And Water	y	y	y	y	y	y		y	
Construction	y	y	y	y	y	y	y	y	y
Social Issues									y
Energy assessment and monitoring	y	y							

3.2 Support Mechanism for Design Phase assessment:
Based on the previous analysis, a support mechanism for the design phase was devised, which ideally remains the same but incorporates relevant adjustments to accommodate the qualitative and responsive mode of design assessment.

- ***Key Performance areas:*** In conformity with GG 21 standard Key Performance Areas
- ***Sustainability Performance Indicators:*** Earth Check indicators plus additional design relevant indicators

- ***Sustainability assessment:*** Draws on the ABEC template for the assessment and deploys the Earth Check Indicators' revised list for benchmarking process
- ***Certification:*** GB tool to provide the framework to evaluate operator's fulfilment of commitment in post-construction stages to certify for GG 21 certification.

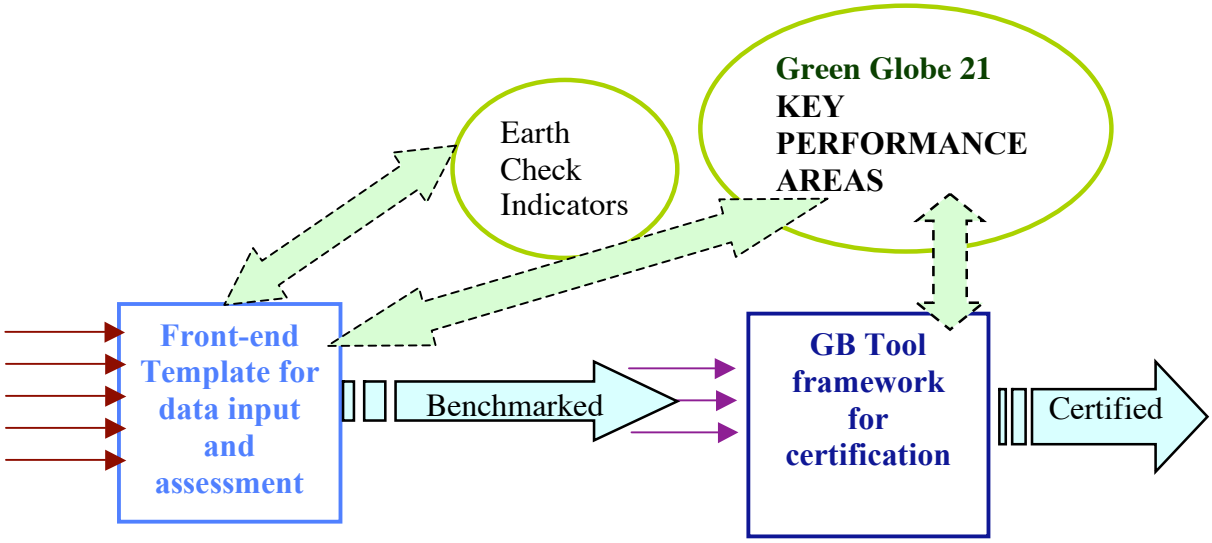

Figure 2: Integration pattern

3.3 Reconciliation of Green Globe, GB tool and the template criteria:

Table 1 and 2 illustrate how each of the criteria in the prospective frameworks of ABEC template and GB Tool broadly comes under the umbrella of GG 21 standard's key performance areas. The next step would be to see the reconciliation pattern in them. The best way to integrate all the criteria in the benchmarking process is to devise a front-end data collection and assessment template. This template needs to be designed so that it covers all design inputs and can form a good checklist for data collection, assessment is done with the help of benchmarks and baseline practices. GB Tool then provides the necessary assessment framework for tracking continual commitment and leads to the certification process. A conceptual integration process is presented in figure 2

4. CONCLUSION

Work has progressed and operationalised for diffusion to the tourism industry. A pilot program is underway for new tourism infrastructure projects. Two projects have utilized the system in the design phase and a number of other projects are underway. The new standard is designed to work with the quality design management process and thus is largely cost neutral to the design process. Thus it is anticipated to facilitate a speedy uptake in the design culture.

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REGEN-LINK: Regeneration and new construction in European social housing Challenges, Knowledge and Solutions

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1. INTRODUCTION

The vast majority of the social housing stock in Europe was built in the period after the Second World War and is in need of improvement and modernisation. Even though the introduction of innovative energy solutions and the adoption of a sustainable approach are more easily applied to new build schemes, earlier demonstration projects already illustrate the possibilities in the existing building stock [Voss, 2000]. The early adopters of this approach within the social housing sector, which owns a large part of the existing stock, have begun to define their strategies with respect to the sustainable redevelopment of existing areas, and have started to execute these in further demonstration projects. REGEN-LINK, is one of those initiatives.

2. REGEN-LINK PARTNERSHIP

REGEN-LINK is a partnership of major players in the social housing sector. REGEN-LINK partners co-operatively address common financial and political issues, thus maximising the practices of sustainable building and energy efficiency at European, national, regional and local levels. REGEN-LINK objectives are:

- To demonstrate energy efficiency, the application of innovative technologies and the reduction of $C0_2$ emissions in urban areas and buildings which are being regenerated
- To integrate efficient (renewable) energy technologies in the designs for renovation and new buildings in regeneration areas
- To integrate innovative energy efficient measures as standard features of the regeneration programmes of social landlords and those engaged in area renewal
- Monitoring and evaluation of results
- Dissemination of the common experiences and results to decision makers, professionals, investors and contractors, in order to promote wide spread acceptance and application of the measures demonstrated

This will underline the benefits of energy efficiency so as to make it possible to integrate the policies of sustainability, energy saving and awareness of these issues into the process of

physical renovation of the buildings which Social Landlords own, or for which they are responsible, or where they are playing a role in the regeneration process.

3. REGEN-LINK PROJECTS

3.1 Eight Sites throughout Europe

REGEN-LINK consists of eight demonstration projects being implemented by Social Housing Builders and Landlords, drawn from North West, Eastern and Southern Europe. In these countries (NL, DK, E, F, IRL, PL, S, UK) social housing demonstration projects in the period from 2000-2003 show that energy efficient housing can become the norm in the regeneration of existing housing areas.
The target is a 25 - 60 % $C0_2$ reduction through the introduction of common energy measures in a variety of contexts and backgrounds.
The projects combine innovation with novel but recognised techniques, so as to demonstrate that energy efficient housing can become the norm in the social housing sector. If innovative technology is to be widely used for new construction and retrofitting then it must be seen to be beneficial to the constructor and to the user [Donze, 2000]. The monitoring, evaluation and interpretation of the results will provide the evidence.

Technical challenges are faced and resolved at the demonstration sites where all measures are introduced according to the threefold strategy (Trias Energetica) of reduced demand (improved insulation, advanced glazing and ventilation strategies), integration of renewable energy sources (passive solar, glazed balconies, double envelope, solar collectors, PV, Heat pumps) and efficient energy supply systems (district heating, small scale CHPs, condensing gas boilers). Thus a broad scenery of market-ready techniques is established and experiences are shared.

3.2 Project example: TØJHUSHAVEN (DK)

The site is located in an urban area of Randers, in the middle of Jutland, Denmark. The project consists of the demolition of 4 four storey buildings dating from the 1900s, and the construction of 4 in fill buildings comprising 36 dwellings.
The project aims to demonstrate cost-effective sustainable urban renewal and the provision of substantial energy savings through integrated design and the creation of a healthy indoor and friendly outdoor environment. Urban site management is to be improved and ideas and knowledge exchanged about energy conscious urban regeneration throughout Europe.
Energy efficient glazed sunspaces and high levels of insulation are added, and a high performance glazing system with integrated lamellas is installed for improved thermal performance and comfort. Radiator-integrated air in-lets provide a fresh air supply into the building. District heating supplies the energy for the heating system. The energy for domestic hot water (DHW) is provided by a combination of photovoltaics (PV) and combined heat and power (CHP), instead of oil and electricity. An energy control, registration and information system, consisting of thermostats, combined control valves and energy meters to control heating, and moisture sensors to control ventilation, are installed. Individual metering is applied for the heating and water supply as well as for the use of electricity.

Energy savings of around 50%, compared to the standard energy demand for new built multi-storey housing in Denmark, are anticipated and a reduction in CO_2 emissions of 661 tons per annum is predicted.

Early in 2002 the project is progressing very well (Figure 1). Relevant monitoring equipment was built in during the construction phase in order to provide the necessary monitored data. National articles about the "Casa Nova" project have been published and the production of a national project brochure has been initiated.





Figure 1 Tøjhushavevej 4 and 5 renovated (Randers, DK)

Advanced high performance glazing with integrated Venetian blinds were designed for the South facing facades. The windows can be opened during hot and sunny periods. Photovoltaic panels as a complete roofing system for one of the four buildings have been implemented.

4. COMMON TASKS

4.1 Technical and non technical issues

A Common Task Programme has been developed in conjunction with the demonstration projects. The programme builds upon European and international experiences and breaks new ground in co-operation between Social Landlords and professionals. It provides solutions to common financial and political issues, which can maximise the practices of sustainability and energy efficiency at European, national, regional and local levels

REGEN-LINK partners co-operatively address common issues such as design, monitoring, building and urban sustainability, peer reviewing, tenants involvement, finance and dissemination.

4.2 Example Task 7: Non-technical strategies

Apart from the more or less traditional technical issues in demonstration projects, special attention is paid to crucial strategic economical and social aspects. One of the joint activities is the Common Task entitled “Non-technical strategies: Policies, Partnership, Personnel motivation and awareness”, for which the Spanish partner is responsible.
In this task REGEN-LINK partners will finally define a clear set of energy efficiency and sustainability objectives. They also seek new partnerships to reach these objectives. The collective commitment that is needed from all the personnel of the companies involved should be developed in every institution.

4.2.1 Delphi questionnaire. A first step was taken with a Delphi questionnaire [Ezquiaga, 2002]. This method is an element in a progressive search whose goal it is to obtain conclusions from a panel of experts. The questionnaire was devised as a means of assessing the awareness and motivation of each site's project partners on urban sustainability. Urban sustainability is far from being the dominant paradigm in the building industry. All people, technical or financial staffs, who work in the project, are seen as partners in this approach. A questionnaire addresses the awareness of each partner. Therefore, its results are categorised as perceptions of a normative and industrial framework, not as a faithful reflection of the current situation. The form is arranged in four chapters:

- Intending to offer a profile of the person reacting and offering a description of the project
- Addressing the incidence of urban sustainability policies
- Studying the partnership between the parties involved
- Intending to provide a vision of the awareness of the participants.

Results have shown that the work structures are quite diverse across Europe in terms of partnership schemes, but some features are common.
A selection of preliminary outcomes is presented below.

4.2.2 Urban Sustainability Policies. On the subject of urban sustainability policies it is concluded that a significant proportion of a Local Agenda XXI or of an Environmental Action plan exists in the municipalities, but these documents do not often set goals or indicators for energy efficiency.
Energy saving and efficiency are regulated in all countries at the state level (Figure 2).

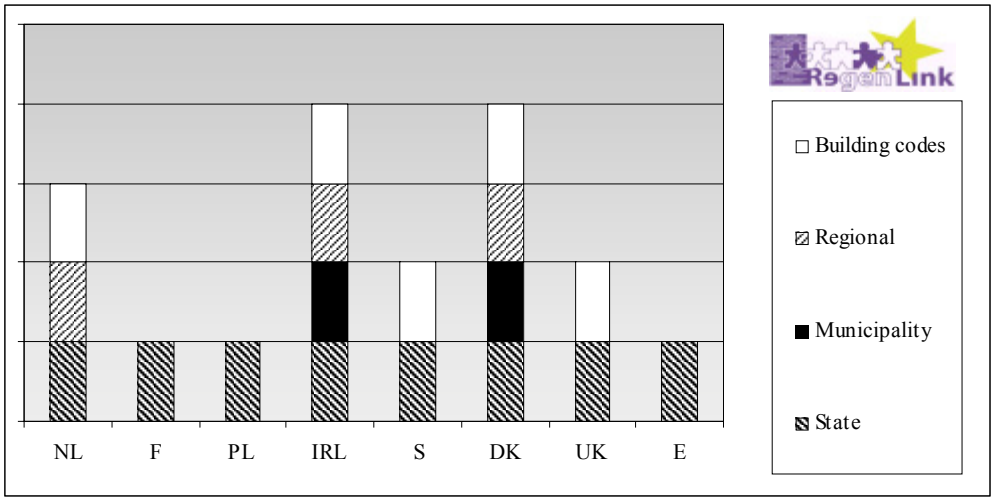

Figure 2 Level of codes including specific binding measures on energy savings and efficiency

Utilities and public works are generally not regulated in terms of energy efficiency, even at state level. This means for instance that losses from pipes and ducts are supposed to be addressed by utility companies on a profit basis.
A common wish is to introduce higher standards for energy efficient design. Polish and Dutch sites also propose the reuse of older building materials.

4.2.3 Local Partnerships. Problems mentioned within partnerships while environmental criteria are being implemented are:

- Unclear definition of what is really environmentally sustainable
- Lack of a perception of building costs as an element to be assessed in the long term
- An increase in the number of partners involved (more complications, time and effort)

4.2.4 Awareness of participants. Nearly all the projects have devised ways to translate their experience on environmental issues to future projects by maintaining the technical staff.
Housing tenants have shown an interest in environmental improvements in all projects. Energy efficiency is a general concern, regardless of the location of the site. French and Dutch inhabitants have also shown interest for air quality measures (Figure 3). Daylight control features have been of interest to the French, and the Danes have shown curiosity about the materials employed.

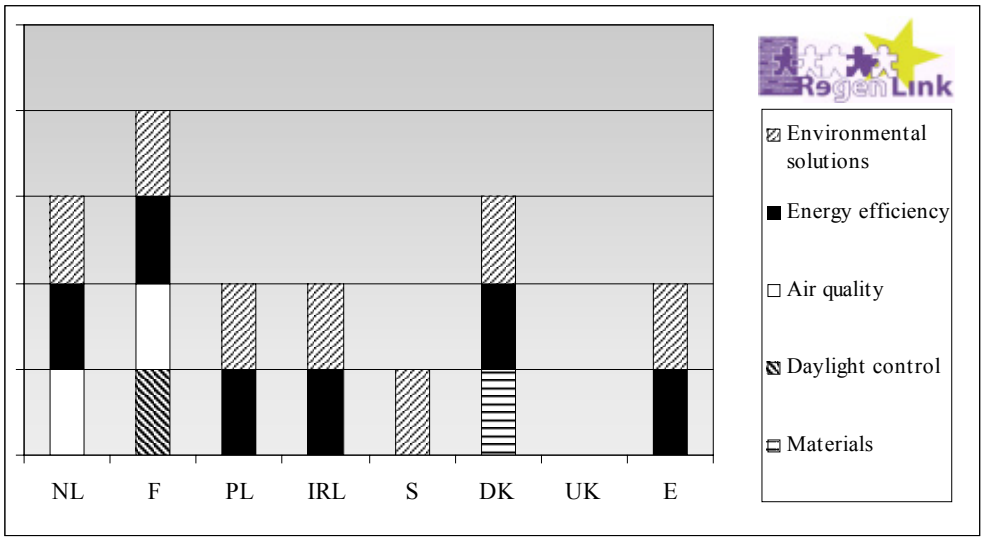

Figure 3 Inhabitants interest in building features

When asked for the principle reasons that make it unusual for environmental criteria to be applied to social housing, the answers deal mainly with the lack of local authority awareness and inhabitants interest, awareness, cost perception and industrial culture.

4.2.5 First conclusions. The results of this phase of the Delphi method show that developing a refurbishment or new social housing project on environmental awareness implies additional cost and extra time, as perceived by the partners themselves. But it seems these extra requirements are in closer relation to the experimental nature of the projects than to a genuine problem of environmental requirements. The main proposals to increase the environmentally aware housing operations are focused on information and education, and on the implementation of standards that can overcome the experimental character of the projects. These standards should be applied both in norms and in the certification of building materials.

5. OUTLOOKS

REGEN-LINK concentrates on sustainable urban renewal, creating links with policy issues on both international and local levels. REGEN-LINK started early in 2000 and activities on the demonstration projects and Common Tasks will span until the end of 2003. Dissemination has started and will continue a little longer than the end of 2003. The overall progress will be presented at the Sustainable Building Conference 2002. For this, site projects will be addressed briefly and be used for illustrating the main objectives of REGEN-LINK. The main focus will be on the actual outcomes of both technical and non-technical joint activities. Strategies will have to be targeted at participants specific roles, opportunities and motivation [Donze, 2001].
It centres round the main objectives of the Conference and offers a broad perspective and survey of the complexity of sustainability in the regeneration of existing areas. Challenges are faced, knowledge gained and spread, solutions shared.

REGEN-LINK is a partnership of major players in the social housing sector in Europe and EU-supported within the Fifth Framework Programme.
First two authors are Technical/Scientific Co-ordinators of REGEN-LINK.
More information: www.REGEN-LINK.org.

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Greening University Construction: A Case Study at the University of Florida

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1. INTRODUCTION

Rinker Hall, about to be the home of the M.E. Rinker School of Building Construction, is the first building on the campus of the University of Florida to be built exclusively with emerging "green" building technology. The need for a new building was established and a team of dedicated architects and planners designed Rinker Hall to achieve a gold rating in accordance with the U.S. Green Building Council Leadership in Energy and Environmental Design (LEED) standard.. The School of Building Construction has emphasized that this project will minimize negative environmental impacts of the building at local, regional, and global scales during the construction process and throughout the operational life of the building. Future growth and expansion has been accounted for, and many issues such as daylighting, waste reduction, noise reduction, and energy savings are addressed by the design. The extremely high potential for energy savings mean that Rinker Hall is an excellent model for design and construction practices for future University of Florida facilities. More importantly, Rinker Hall served as the impetus for all new construction on the campus to be built in accordance with the LEED standard. This marks a sea change in the way construction is accomplished at the University of Florida and it will have impacts throughout the State due to the educational value of this cutting edge approach. This is especially important because Florida, with a population of 17 million , is the fastest growing U.S. state, and larger than many countries in area, population, economic output, and consequently, in environmental impacts.

2. BACKGROUND

The M.E. Rinker, Sr. School of Building Construction, established in 1935, is the oldest continuing construction program in the nation, and the first in the United States to have a graduate program in construction. In 1965, representatives from eight other construction institutions met in Gainesville, Florida to form the Associated Schools of Construction, of which the school is a charter member. Rinker was one of the first programs to receive accreditation from the American Council for Construction Education and has been recognized as an outstanding program by the Associated General Contractors Education and Research Foundation. It is the largest, oldest, and most prestigious school of its kind in the nation, and its enrollment, faculty, research programs, and public service programs are growing at a rapid pace.

Recently, however, there were deficiencies in the accreditations report related toward the lack of facilities to provide a program equal to the reputation of the school. The School of Building construction is currently using temporary space on one floor of the Fine Arts Complex

(building 599) and a portion of the basement in the Architecture building (building 268). One major problem is that there are no operational testing or construction laboratories. While there are rooms designated as lab space, these are in actuality nothing more than storage space for equipment. As the size of the student body continues to increase, so does the demand for additional classroom, office, lab, and research space. Currently, the school can only meet about two-thirds of this demand. In addition, the current facilities are unable to meet the demands for network communications and electronic technologies. Unlike some departments, few construction classrooms have built-in computer projection equipment or network connections. The School currently faces a serious challenge in maintaining its position as a leader in construction education and therefore a new facility was considered a priority. The solution to these problems was to create a new building, Rinker Hall, that would provide the laboratory space and additional classrooms as well as provide a state of the art facility with respect to internet connectivity, telecommunications, and space for research (Figure 1).



Figure 1 Renderings of Rinker Hall at the University of Florida showing the brick façade located about one meter from the actual building.

3. PROJECT GOALS AND DESIGN OBJECTIVES

The design of the new building is closely related to the academic plan for the School and has taken future growth into consideration. The building is organized according to the three student blocks in four classes of undergraduates. These blocks dictate the shape and size of the classrooms, labs, and shops. They also organize the faculty offices and support spaces, drawing relationships between professors and their classes.

Major directives from the School are to minimize negative environmental impacts of the building at local, regional, and global scales during the construction process and throughout the operational life of the building. The design is intended to optimize the use of energy, minimize disturbances to local ecosystems, and provide a healthy, daylight–filled workspace for faculty and students. All materials and finishes chosen for the project contain a minimum amount of harmful substances and, wherever possible, the materials will be manufactured with recycled content.

Several design-related issues are important to the project, and are typical of projects located on the University of Florida campus. These include the following:

- **Budget:**
  The total project budget is $8.2 million with an estimated construction budget of $7.1 million.
- **Tree Preservation:**
  The preservation and protection of trees is of high priority at the University of Florida and existing trees will be saved and incorporated into the design wherever possible. The construction of this new building will strictly adhere to the current University Tree Protection Policy.
- **Transportation:**
  Bicycles and walkways are primary modes of transportation at the University of Florida. Site design on this project will include adequate walkways that are integrated into the existing pedestrian circulation network, and a sufficient number of bicycle parking facilities. Design of this building also intends to make a strong separation between pedestrian and the vehicular traffic. Easy access for pedestrians and bicyclists will be given first priority in the circulation plan.
- **Future Growth:**
  As far as the program and budget allow, site and building design will allow for future growth and change. This flexibility gives the facility an extended usable lifespan by incorporating features for remodeling and expansion that will reduce future renovation costs.
- **Material Context:**
  The use of Gainesville Range Red Brick for the major portion of the exterior finish is required in order to serve as the primary visual element. This style is used consistently in all facilities at the University of Florida.
- **Cultural Concern:**
  An existing memorial resides on the site in memory of UF students and faculty that perished in an accident. This monument is to be moved and incorporated into the landscape design. This initiative demonstrates a responsibility to culture issues and is sensitive to the students and faculty of the university.

Most importantly, the design of Rinker Hall is intended to enrich the University of Florida campus functionally and aesthetically. It will relate to adjoining buildings, not compete against them. It also marks an attempt to create a new vernacular for the campus, shifting from heavy energy absorbing structures to lightweight energy shedding buildings.

4. SELECT GREENING OBJECTIVES

4.1 Construction Waste

Construction waste, which comprises a significant portion of landfill volume, is another major concern. The contractor is required to employ processes that generate as little waste as possible. Most construction waste can be attributed to worker error, poor planning, material breakage, mishandling, or contamination. While some waste is inevitable, careful planning is expected to minimize this.

4.2 Material Specifications

Rinker Hall's material selection emphasizes renewable and recyclable resources. For example, instead of vinyl composite tiles (VCT), a chlorine-based material typically used in campus buildings, linoleum is specified. Local materials have also been specified to reduce environmental impacts and energy costs associated with the transporting these goods over

long distances, and to support the local/regional economy. The building as a whole is designed for deconstruction (DfD) to facilitate the reuse and recycling of the structure at the end of its useful life.

4.3 Recycled Materials

Rinker Hall will also be constructed with recycling in mind as the life of the building comes to an end. One way to do this is by selecting building components that can be recycled or disassembled. Structural steel framing can be reclaimed and reused easily, and is being used in Rinker Hall. Aluminum will be used in building components instead of plastic alternatives for the same reason (and because it will reduce building heat-gains). Aluminum provides a subjectively better, more visually appealing choice of material than plastic, making for a more aesthetic building. Aluminum components also tend to perform bette and last longer than plastic components. Natural materials such as wood and cork are used in preference to plastics or other synthetics, since the organic materials of these natural products will be easier to compost at the end of their useful life. Cork and wood materials can also be harvested in a sustainable manner, helping to reduce the ecological footprint of Rinker Hall. As with aluminum, cork and wood products are also more pleasing to the eye, and generally have superior performance functions than plastic or vinyl products.

4.4 Indoor Air Quality

It will be important for Rinker Hall to achieve the highest indoor environmental quality for the health and productivity of its occupants. To this end, Rinker Hall will only use types of materials such as carpeting, paint and wallpaper that give off little or no volatile organic compounds. As a fossil-fuel based product, carpet is a questionable choice for environmentally sound buildings. Disposal after the carpets useful life also creates problems because recycling of the constituent components is very difficult. Carpets can trap and hold volatile organic compounds such as formaldehyde. In Florida, carpets are especially prone to mildew, mold, and dust mite infestation. There are strong indications that carpet can be a strong contributor to “sick building syndrome”. For these reasons, little or no carpeting will be found in Rinker hall. The LEED standard allows credit for use of low emitting materials.

4.5 Site Issues

The LEED standard has strict requirements with regard to building site. Since the site was formerly a parking lot, the building will have a positive effect on the surrounding environment, and could be considered infill. A site sediment and erosion control plan was implemented for Rinker hall. Soil loss from the site during construction will be minimized by following the best management practices outlined in the U.S. Environmental Protection Agency’s Storm Water Management for Construction Activities document. Because the site is nearly level, erosion and soil loss was not a strong consideration during design. To reduce the site disturbance, care is being taken to preserve existing trees and vegetation and much of the landscaping will occur after construction is complete to provide habitat for wildlife and create a pleasant microclimate around the building. Strategically placed shade trees will help cool the building during the hotter months of the year.

4.6 Landscaping

The water efficient landscaping requirement of the LEED standards will require Rinker Hall to use only indigenous plants for landscaping. This requirement is not onerous, as north central Florida has numerous native plants that are both attractive and require minimal irrigated water. Irrigation for any landscaping will come from the campus reclaimed water system.

4.7 Energy Efficiency

LEED requires the building to meet stringent energy efficiency standards. These standards will be easily met by Rinker Hall, since building energy use was optimized through computer modeling, which combined the contributions from daylighting, mechanical/instrument systems, efficient lighting, and a superior building envelope. LEED provides additional credit for optimized energy performance, and Rinker Hall will earn additional credits for its superior system. Computer models were used to optimize building energy use. These models, and the resulting design, combine daylighting, advanced mechanical systems, energy efficient lighting, control sensors, and an improved building envelope. One critical high-performance component is the building wall. This is designed with a nominal R27 (effective R15) thermal resistance as well as an air infiltration barrier that prevents water vapor from passing into the interior wall cavities, thus preventing any condensation that might deteriorate building components or promote bacterial growth. Figure 2 shows the wall construction and louver placement. Rigorous quality control during construction is essential to the effectiveness of this high-performance wall that, upon completion of the project, will be subject to an independent pressurization and smoke test to verify performance.

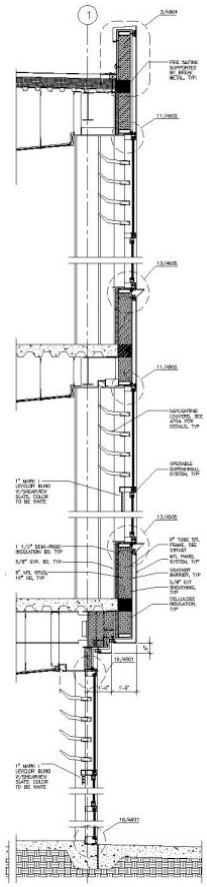

Figure 2 Wall section showing daylighting louvers at each story of Rinker Hall

4.8 Daylighting

Daylighting is the use of natural sunlight for interior illumination through perimeter windows, roof windows or skylights, or specialized light pipe systems. Daylight is a superior

alternative to fluorescent lighting in that it provides a higher quality light, that is, it provides full-spectrum light (an illumination more evenly distributed across the light spectrum). Improvements in health, productivity, and well-being are some of the greatest advantages offered by the use of daylighting. Recent statistical studies involving 21,000 students in three states reveal that students perform better in daylit classroom, indicating the health benefits of daylighting.

There are also economic rewards for daylighting, though they take several years to accrue. Daylighting can reduce the costs of cooling a building, since the ballasts and bulbs of fluorescent fixtures emit waste heat. A downsized lighting system will require less maintenance over the life of the building. Though quantitative measurements can show improved measures of these indicators of building environment quality, working under daylight is simply more pleasant that working under the flickering light of florescent bulbs, meaning Rinker Hall will naturally be a more desirable place to study. LEED standards give credit for successful use of daylighting.

4.9 Water Efficiency

Rinker Hall is also a very water efficient building and incorporates a rainwater harvesting system comprised of a rooftop collection system, piping, and a cistern for storing the collected water. The rainwater is used for flushing toilets. Waterless urinals are also specified for this building, meaning that the potable water profile of Rinker Hall is extremely low. The landscaping is maintained using the campus' reclaimed water system, that is, water from the wastwater treatment plant.

5. CONCLUSIONS

The importance of Rinker Hall to the University of Florida and the State of Florida should not be underestimated. The University is the most prominent educational institution in the State and one of the most important in the U.S. As the 'flagship' university for Florida, the other ten large State universities look to it for leadership in every arena, not the least of which is in the creation of buildings and the built environment. Rinker Hall will use a fraction of the energy of conventional classroom buildings, harvest rainwater, use waterless urinals, create a healthy interior environment, be able to be disassembled at the end of its useful life, and all its components reused or recycled, as well scores of other positive attributes. Rinker Hall represents a major shift in attitude and reality at the University of Florida and as a consequence, throughout the State. It marks the beginning in once again paying attention to energy efficiency as well as to the impacts of the built environment on nature and ecosystems.

740 Belair Building, Montreal
Setting the Standard for
Sustainable Government Buildings

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WHO IS PUBLIC WORKS AND GOVERNMENT SERVICES CANADA (PWGSC)?

The Department of Public Works and Government Services (PWGSC) is a major provider of central and common services in the federal government. Real Property Service and Supply Operations Services are an integral part of the many services it offers. Real Property operations serve two functions, real property management and real property service delivery, and include professional and technical services, the management, operation and maintenance of real property assets, and construction and environmental services. PWGSC's Supply Operations Service is one of the biggest providers of work in the country. A large number of its contracts are for architectural, engineering and construction services. It is mainly at these two levels that PWGSC plays a major role in advancing sustainable development in Canada.

PWGSC'S ONGOING COMMITMENT

In 1997, PWGSC tabled its first sustainable development strategy in Parliament. Since then, considerable progress has been achieved and many commitments have been made in order to meet sustainable development strategy objectives. The Department is committed to:

- incorporating an exhaustive environmental management system into its overall management framework and ensuring that environmental performance standards are met and maintained according to set objectives;
- promoting the greening of the Department through pollution prevention measures and complying with or even going beyond the minimum required by policies and regulations;
- promoting the greening of daily PWGSC operations by implementing green citizenship practices;
- helping clients in their environmental initiatives and encouraging them to seek out environmentally friendly goods and services.

The strategy focusses directly on construction project and building operations management. The 740 BEL-AIR construction project is a perfect example of how the strategy can be implemented. It is the first major project in the Quebec Region that incorporates the concepts of deconstruction and green buildings and will serve as a model for future construction projects in both the public and private sectors.

THE 740 BEL-AIR PROJECT

PWGSC owns a 10,700-square-foot lot in Montreal's west end. The district is known for its industrial past, and industry and residential areas still co-exist. The lot is identified as 740 Bel-air in Montreal. It has a real property complex consisting of eight buildings built between 1875 and 1950. Over the years, the buildings have undergone many changes to meet the various needs of successive occupants. The federal government has owned the lot since 1949. It was initially used by the Department of National Defence (DND) until 1971, and two federal departments occupy 75% of the premises today. In addition to the work required to meet current occupants' needs, a recent study on the property's condition shows that much work is needed to bring the buildings up to code.

Activities carried out on the site from the time it was first occupied and modifications made to the buildings over the years do not meet today's environmental standards. PWGSC owns a site with major environmental problems:

- the soil is contaminated by various metals and PAHs;
- PCBs have been found in electrical equipment and insulation contains unsealed asbestos in a number of places;
- the paint has a high lead content.

In July 2001, PWGSC, Quebec Region, received preliminary approval from Treasury Board to rehabilitate the site. The new building must be built on the 740 Bel-air site. It will meet the accommodation needs of the armoury of DND's Donnacona Naval Reserve, the Royal Canadian Mounted Police and two other departments.

From the outset, the objective of the PWGSC project team was to implement the sustainable development strategy into each production phase. This generally entailed:

- choosing an alternative energy source to reduce greenhouse gas emissions, instead of using a conventional energy source;
- promoting the recovery of materials (recycling, re-use and processing), thereby reducing demolition waste;
- minimizing the building's operating and maintenance costs;maximizing natural lighting and air quality;
- maximizing natural lighting and air quality;
- using environmentally friendly materials.

Because this is the first project of its kind in Quebec, the deconstruction approach and the selection of consultants and a demolition contractor required us to adjust some of our standard practices.

1. <u>Deconstruction on the demolition site</u>

   Considering the needs of future users, the project team decided to preserve two existing buildings and incorporate them into the new plans. This decision was essentially based on two factors: the buildings' composition and their ability to meet users' needs. Deconstruction, as opposed to demolition, is not standard practice in Quebec because of the low cost of burying dry waste. It is currently less expensive for contractors to demolish than deconstruct. Aware of the waste recovery market, which has yet to become firmly established, we opted for an approach requiring contractors to recover as much waste as possible.

The buildings and the materials of which they consist were first surveyed to determine which materials could be re-used, recovered and recycled. Studies were conducted on each of the materials identified with the help of public, parapublic and private organizations in order to determine recycling or re-use options. This information was used to prepare calls for tender for the buildings' deconstruction. A minimum recovery objective was established for each category of material, and contractors were required to meet these objectives. In their bids, contractors had to explain how they would meet these objectives and where the materials would be recovered. At no time will the contractor be permitted to remove materials from the site without indicating its destination and intended recovery. We have received contractors' bids and work is expected to start on August 5, 2002 and run until November 30, 2002.

In addition to minimizing the practice of burying dry materials, the purpose of the project was to stimulate Quebec's recycling market, obtain information on the pros and cons of this approach and share this information with various stakeholders.

2. Selecting the team of consultants

Additional requirements in request-for-proposal documents were included for the selection of the team of architectural and engineering experts mandated to produce the plans and specifications for the new building in order to ensure that the team incorporates all sustainable development concepts into its plans. The requirements essentially consisted of:

- designing the building according to LEED gold level criteria;
- meeting a list of minimal performance standards in the main fields of activity (water management, energy, air, materials, etc);
- providing an environmental coordinator who would be part of the team to ensure that all environmental objectives were met.

The project's design phase will be completed by August 20 and the creation of a building that will meet LEED gold level environmental performance standards is practically guaranteed. Given Quebec's climate, the project's mechanical and architectural designs must ensure that the building is operational in temperatures that may vary between -25ºC and 30ºC and in relatively high humidity. The preliminary mechanical plans and the design plans are to be made available during the presentation. The main elements included in the design are:

- recovery of rainwater for toilets;
- a leaching basin for greywater;
- natural ventilation with a complementary mechanical system (air humidification and dehumidification)
- hot water radiant heating and use of geothermics;
- use of environmentally friendly materials

CONCLUSION

The approach used to carry out the project is innovative and will serve as a reference for future projects in the Quebec Region. All deconstruction phases and, especially, the results obtained will be shared with various organizations to help the deconstruction market become established. The parameters assessed in developing a green building, project structure, performance assessment and comments received once the building is operational will also be made available for future projects. Cost information will be compared with that of a conventional project in the Region.

We would like this project to become a model for designers, contractors and users that will help promote the advancement of green buildings in similar climatic conditions.

Whole Building Life Cycle Energy and Environmental Impacts: The Significance of Energy and Water Services Burdens in a New University Building

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1. INTRODUCTION

Many evaluations of the environmental performance of buildings have been undertaken (Cole and Kernan 1996), (Buchanan 1994), (Suzuki and Oka 1998). Often these studies are built on generic building characteristics. This project was undertaken to conduct a comprehensive Life Cycle Assessment (LCA) of a contemporary university building based on a detailed material and operational inventory. While previous LCAs have generally indicated that operational activities dominate environmental impacts, this project stands at the extreme of that scale. This paper emphasizes the need for accommodation of individual life span building characteristics in building environmental assessment.

2. METHODS

The Sam Wyly Hall (SWH) LCA is conducted in accordance with EPA (Vigon, Tolle et al. 1993), SETAC (1993), and ISO (1997) LCA standards. Data sets come from the DEAM™ database (Ecobilan 2001), the Swiss Agency for the Environment, Forests and Landscape (1998), SimaPro software (PRe 2000), and Franklin Associates(1990). An article documenting the full SWH LCA is currently under review (Reppe, Scheuer et al. 2002). A brief recapitulation of relevant details is included here. If readers have questions about specific contents of that paper in regards to this paper please contact Chris Scheuer.

2.1. System definitions, boundaries and data sources

SWH is a 7,306 m^2, 6-story building completed in 1997 on the University of Michigan (UM) campus in Ann Arbor, Michigan. The basement and floors 1-3 are classrooms and open-plan offices, floors 4-6 are used as hotel rooms. The life cycle activities of the SWH LCA are illustrated in Figure 1. The SWH LCA covers the building structure, envelope, interior and backfill. A 75-year life span is presumed. It is further assumed that the energy mix will be constant over the life span. The following sections describe the activities and boundaries for each life cycle phase.

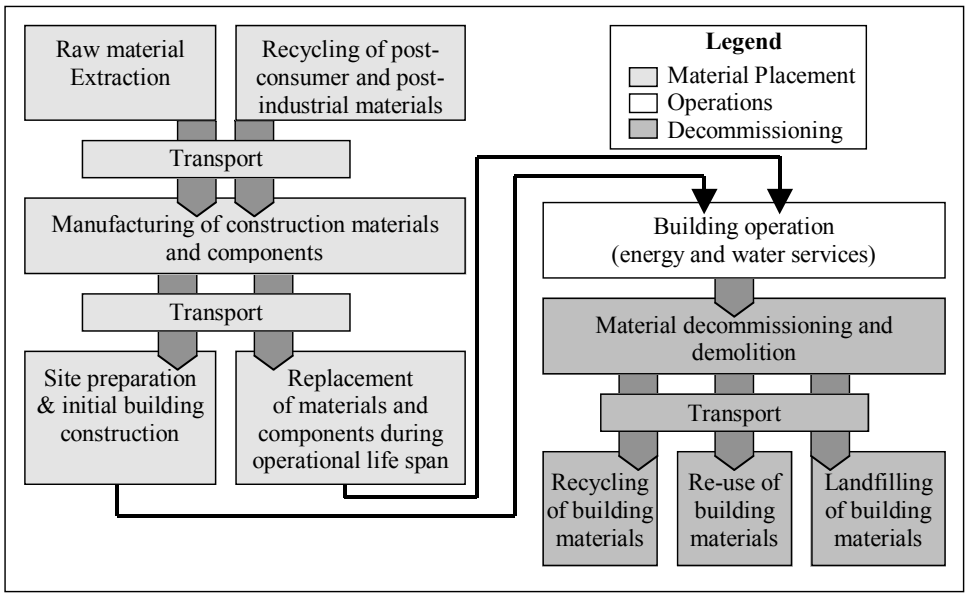


Figure 1 Life Cycle Activities

2.1.1. Material Placement. Material placement encompasses all activities required to design, construct, and renovate a building throughout its life span. These activities include material production, transportation and construction/renovation. The material inventory includes burdens associated with raw materials extraction and manufacturing. Replacement materials are modeled with the same energy and environmental burdens as the initial installed materials. "Total embodied energy" is material embodied energy plus primary energy for transportation and construction. Generally the data sets used account for transportation burdens from the point of extraction, to the manufacturer, thus transportation covers shipping of materials from manufacturing site to construction site. Energy and environmental flows associated with the construction process could not be developed directly, therefore the Canadian Athena (2001) model and work by Cole (1992), (1996) is used to estimate construction energy.

2.1.2. Operations. Operational activities consist of heating, cooling and ventilating the building, water supply and waste water treatment (based on results from a recent water services LCA)[1], water heating, lighting and equipment operation. Architectural, mechanical and internal loads and use patterns are modeled in Energy10 (NREL 1997). For SWH about 70% of the annual electricity and all of the heating and cooling steam is generated in a natural gas (NG) boiler and turbine driven combined heat and power plant (CHP). Due to difficulties in modeling the UM CHP a NG industrial boiler data set and a NG turbine data set were used to model heating/cooling and the university portion of electricity production respectively. The remaining 30% of electricity is provided by the local utility, and is modeled with an ECAR grid electrical production data set.

2.1.3. Decommissioning. As demolition data for SWH is not available, a Canadian study of structural deconstruction is used to estimate demolition energy (ATHENA 1997). This study assumes material recycling[2] based on common industry practices. Following the U.S. E.P.A. "Second Allocation Method" (Vigon, Tolle et al. 1993), recycling benefits SWH only by reduced waste generation, not by reduced material embodied energy.

[1] forthcoming, from the Center for Sustainable Systems, http://css.snre.umich.edu
[2] Concrete, CMU, mortar, brick, granite, ceramics, All metals, window glass, carpets, ceiling tiles.

2.2. Omissions and modeling assumptions

The LCI is developed from a variety of sources, both national and international, which were the best available options within the scope of this project for representing the materials and systems present in SWH. Material production and manufacturing process data sets cover approximately 97.1 % (by mass) of total material requirements. For another 2.7%, surrogate data are used (e.g. bottle glass instead of flat glass), or material production data sets alone are used to model fabricated building components (e.g. gypsum and kraft paper for drywall). Finally, 0.2% are not included because no data are available. The following elements were excluded from the scope of this project: office equipment, moveable partitions, and furniture, street and sidewalk modification, site location and local infrastructure impacts, planning and design of the building, and miscellaneous construction materials.

3. RESULTS

3.1. Energy demands

3.1.1. Material placement. The total primary embodied energy is 55 $x10^3$ GJ over the building lifecycle. This represents only 4.5% of life cycle energy demand (compared to 15% for Eaton (1998) and 12% for Cole (1996)). Of this, 91% of material placement primary energy is from material production, while transportation and construction account for 4% and 5% respectively. Replacement of materials through renovations accounts for only 1.4% of life cycle primary energy demand. In previous studies (Howard 1996), (Cole and Kernan 1996) embodied energy from renovations accumulates rapidly, and often exceeds initial material embodied energy. This is partially due to the high embodied energy of two materials commonly part of commercial renovations - carpeting and wiring. Because it is a university building, SWH will have less frequent renovation cycles than most commercial buildings, which diminishes life cycle material embodied energy. Total embodied energy in SWH equals 8.1 GJ/m^2, (compared to "initial embodied energy" of 4 to 12 GJ/m^2 reported by Cole (1996)). Another significant contributor to this project's lower embodied energy is the material production energy factors used for steel. Cole (1992) found ranges of 25-39 MJ/kg, other studies have also used high energy factors for steel (Buchanan 1994), (Eaton and Amato 1998). This study uses a range of 14 MJ/kg (hot rolled secondary steel) to 30.6 MJ/kg (galvanized steel), which generally led to lower embodied energy results.

3.1.2. Operations. Figure 2 shows the life cycle distribution of primary energy. The operational phase of SWH dominates life cycle energy consumption. Building operations represent 95% of the primary energy (1.2 x 10^6 GJ). Use of NG accounts for 63% of the total life cycle primary energy use. Grid supplied power, while only 30% of site electricity, represents 45% of electrical production primary energy, due to the low efficiency of the regional grid compared to the NG turbines.

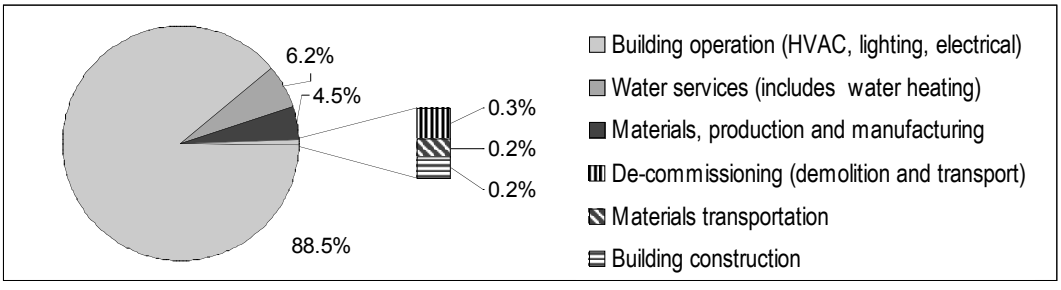


Figure 2 Life cycle energy distributions

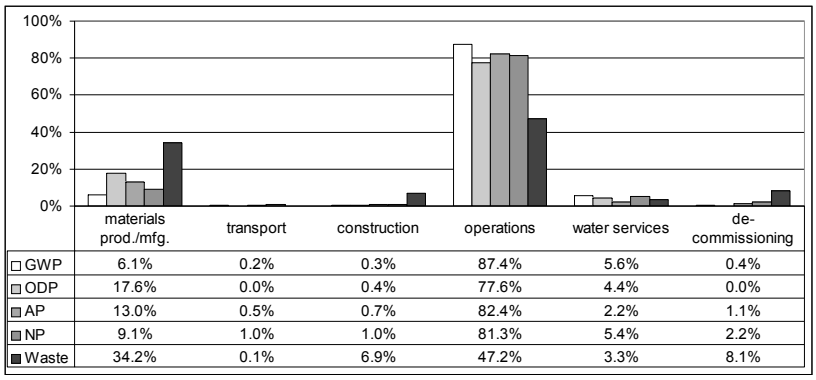
The primary energy burden for water services (75 x 10^3 GJ) is greater than total embodied energy. NG hot water heating accounts for 94% of water service primary energy, while potable water production and wastewater treatment together only account for 6%. Consumption of cold and hot water is primarily due to the hotel rooms on floors 4 - 6.

In SWH, operational primary energy exceeds initial embodied energy after only 2.5 years (3.5 years for total embodied energy). This number is on the lower end of results from Cole (1996), and Eaton (1998) [3], who found 2.6 - 4.6 years and 5 - 8 years, respectively.

3.1.3. Decommissioning. The energy requirements for decommissioning (demolition and transportation) represent only 0.3% (4.0 x 10^3 GJ) of life cycle primary energy demand.

3.2. Life cycle environmental impacts

The measured environmental impacts from SWH (based on current literature (Leiden University 2000)), followed closely the energy consumption profile in many aspects, a notable exception being that water burdens while consuming more energy produce less environmental impacts than material placement. The largest contributors in most of the impact categories were emissions related to fossil fuel combustion during the operational phase. Relative impact assessment results are summarized in Figure 3 with details provided below.



	materials prod./mfg.	transport	construction	operations	water services	de-commissioning
GWP	6.1%	0.2%	0.3%	87.4%	5.6%	0.4%
ODP	17.6%	0.0%	0.4%	77.6%	4.4%	0.0%
AP	13.0%	0.5%	0.7%	82.4%	2.2%	1.1%
NP	9.1%	1.0%	1.0%	81.3%	5.4%	2.2%
Waste	34.2%	0.1%	6.9%	47.2%	3.3%	8.1%

Figure 3 Life cycle distribution of environmental impacts

3.2.1. Measured Impact Categories. Life cycle Global Warming Potential (GWP) over a 100-year time horizon for SWH was 74000 tonnes of CO_2 equivalent. Operational phase CO_2 releases alone account for 84% of life cycle GWP. Life cycle Ozone Depletion Potential (ODP) for SWH is 0.4 kg of CFC-11 equivalent. Operational phase electricity production accounts for 75% of life cycle ODP. The total life cycle Acidification Potential (AP) for SWH is 222 tonnes of SO_2 equivalent. SO_X and NO_X emissions from operational phase grid-electricity generation and NG production cause 57% and 17% of total AP respectively. The life cycle Nutrification Potential (NP) for SWH is 24 tonnes of PO_4 equivalent. NO_X emissions from operational phase grid-electricity generation and NG production cause 39% and 20% of total NP respectively. SWH life cycle waste generation is 6,867 tonnes. Material production wastes were primarily mining/extraction wastes from cement, copper and sand production. Just over half of life cycle waste generation comes from the operational phase, unspecified process wastes and slags and ashes from grid electrical production account for 38% of life cycle waste. Landfilled materials (7.8%) are relatively low due to the assumption

[3] Cole (1996) considers embodied energy to include burdens from transportation and construction, but not replacement of materials. Eaton (1998) considers embodied energy to include burdens from transportation but not construction or replacement of materials.

that the most massive building materials will be recycled or reused (e.g., concrete, sand, gravel, CMU, Brick, all metals, carpets).

4. CONCLUSIONS

Life cycle distribution of energy consumption, environmental impacts and solid waste generation is concentrated in the operational phase of this case study building. In all measurements, except waste generation, operations account for more than 78% of the burdens and impacts. In two key measures, primary energy and GWP, operations accounts for over 93% of life cycle burdens. While energy burdens from water services exceed energy burdens for material placement, for other measured environmental impacts water services account for less than material placement.

Two factors specific to this building contribute most directly to the higher than expected concentration of operational phase environmental burdens. First, several materials frequently renovated (especially carpeting and wiring) are found to have high embodied energy. However, SWH is an institutional building with replacement schedules significantly lower than those found in other commercial buildings, so this expected impact is minimal in this case. The combination of hotel rooms with a classroom/office building greatly intensifies water consumption. While these two factors exacerbate operational phase impacts, the 70% CHP / 30% grid power model utilized does reduce total operational impacts because of the higher efficiency of NG versus the grid. In a setting with more frequent replacement cycles, and no hotel rooms, but with grid only power sources the operational phase emphasis could be as extreme.

While material choices for environmental performance have received a large amount of attention, this study revealed that at least in some cases their contributions to lifecycle environmental performance could be minimal. University buildings often have unique profiles so individual assessments of life span demands at an early stage can assist in developing appropriate choices for environmental improvements. Existing generalizations about buildings may be inappropriate for a university or other institutional building. Based on this project, a consideration of water needs, and renovation schedules are among the parameters that should be accurately assessed to provide a more thorough environmental profile of a building. Not before the magnitude of material placement environmental impacts more closely approximates life cycle operational impacts, should material strategies be emphasized over strategies for improving operational performance.

4.1. Acknowledgments

The SWH LCA project was supported through a grant (no. F003765) from the Building and Fire Research Laboratory, National Institute of Standards and Technology (NIST). Barbara Lippiatt serves as the project manager at NIST for this research initiative.

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How Daylight Utilization Reduces Environmental Load of a House - A Case Study in a High Density Residential Area

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1. INTRODUCTION

Recently, measures for controlling global warming are strongly requested, and plan and execution of the way to control the carbon-dioxide emissions are social problems. Against this background, Ministry of Land, Infrastructure and Transport started a large-scale project “Low energy and resource saving technologies for autonomous housing and urban infrastructure” in 2001. This project aims to propose the house system of popular type, which does not depend on the infrastructure concerning energy and resource as much as possible.

In this project, each element technology such as light, heat, air, and water and integrated technology to make them circulate are under discussion. The development of the daylight use technology is one of them. In the matter of the daylight use, it is necessary to plan from an earliest stage of housing plan, compared with artificial illumination.

At the earliest stage of the plan, there is no necessity to use those like computer graphics if only it is able to forecast simple brightness. It is also necessary to examine heat from the viewpoint of sunshine. We need to consider the peculiar conditions to Japan such as a new lighting technology in the dense living environment of the city part and the method of the lighting in the Japanese-style. However, the lighting environment design tool that can correspond to these requirements is not developed yet.

For this reason, as a link of the project above, the purpose of this study is to carry out the case study of the daylight use plan in the dense city part in Japan with a design tool of the United States (BDA) which can forecast the situation of the daylight simply, considering the region, and based on the result of the research, to arrange the requirements for the simple daylight environment design tool which can be used in Japan based on the result in research.

2. OUTLINE OF THE RESEARCH

First, the case study plans the daylight use based on the analysis of various environment such as the situation of the site in the midway design plan and describes the process of the results reflected to final design plan. In addition, it describes a qualitative evaluation to the final design plan. Next on the improvement of the effect of the day light use by changing the plan,

each quantitative rough estimated forecast value of the midway and the final design plan are calculated with simulation software (BDA) and the validity of the daylight use plan which was conducted qualitatively is verified. Furthermore, considering some lighting forms to which the existing software cannot correspond such as lightshelf, lighting in Japanese-style room which is peculiar to Japan, finding for the tool development of the Japanese type has been brought together.

3. CASE STUDY

3.1 Qualitative daylight use plan

This case study has been conducted from the midway design stage. The plan of the midway design stage was qualitatively examined from the viewpoint of daylight use based on the analysis of the site.

The site is in the dense region as shown in Figure1, and its shape is long and slender from north to south. There are a lot of two stories of buildings around the site. The south side of the building faces the road, and on the north side there is a vacant space. Because the amount of lighting is rather limited in the site, there are few thinkable plans for using the daylights, such as to improve the amount of lighting from the south, to take a effective lighting system on the third floor because three stories of building is planned, and to make use of the north vacant space. Next, the daylight use was conducted from a qualitative viewpoint to the midway design plan (Figure2). The given viewpoint is the following.



Figure1 The site of case study.

- We devised to take much more windows facing south than a present plan.
- Because the resident includes the seniors, it is necessary to secure an enough amount of the lighting to the Japanese-style room in the north side.
- The plan is reversed from east to west to make the lighting from the courtyard more effective.
- The sun optical lighting system was introduced to secure the lighting from the north.
- The lightshelf and the inclination type ceiling are combined to lead the light into dining and living room.
- To plant trees in the vacant space in the north will make the direct sunlight ease and diffuse.

A final plan was made based on the examination of a qualitative effect of the daylight use at the midway design stage, which was mentioned above (Figure3). The main change points taken to the final design plan are “Reverse of the east and west plan”, “Adoption of the lightshelves”, and “Addition of the south window”. From the viewpoint of the daylight use

plan, the points, which can be judged to have improved this plan, are put together. The result of qualitatively evaluating the improvement point is as follows.

- The lighting part facing south of the Japanese-style room, which is one place in the former plan become two places, and the amount of the lighting has increased.
- Both lavatory and the bathroom came to face the courtyard part, and good balance of lighting became possible there.
- The effect of the lightshelf can be expected of the living room, the dining room on the second floor, and the loft on the third floor.
- The window in the child room increases, and the amount of the lighting increases.

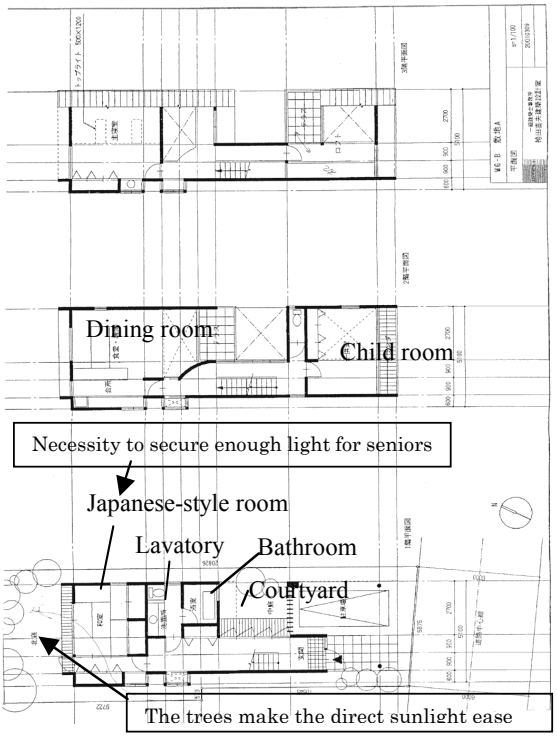


Figure 2 Midway design stage plan.

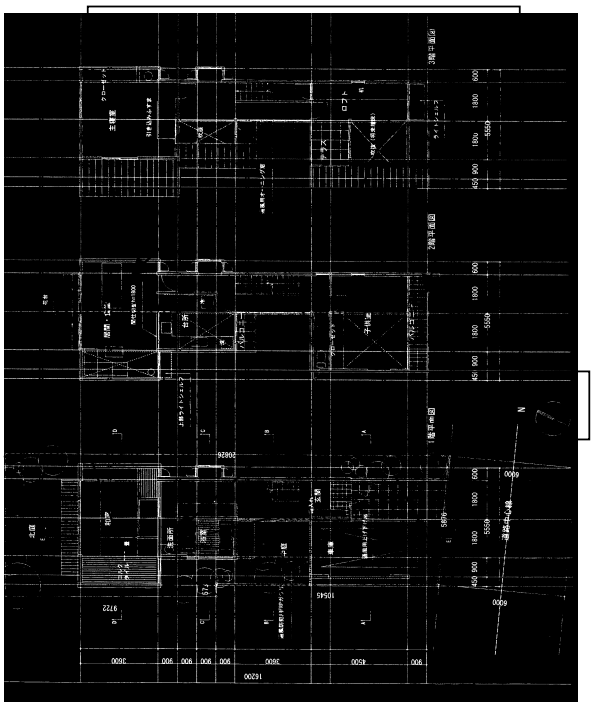


Figure 3 Final design stage plan.

3.2 Quantitative verification of improvement of daylight use effect with simulation tool for earliest design

Here, on the improvement of daylight use effect by the change of the plan, each rough estimate forecast value (illuminance) of the midway design plan and the final design plan was calculated with the simulation software which was developed in the United States recently, and the validity of the daylight use plan which was conducted in the preceding chapter qualitatively is verified qualitatively.

The software used here is an application that operates on Windows named Building Design Advisor (BDA). It is possible for BDA to correspond to a frequent change of the plan and to conduct a prompt simulation because easy CAD is adhered. Moreover, there are some features, that is, it can consider the region and treat other elements except the daylight.

The outline of the executed simulation is explained as follows.

First, the climate that is as similar to Tokyo as possible was chosen on the database as far as we could select. Although the BDA is based on meteorological data and considered the region, it does not correspond to the weather of Japan. For this reason, San Francisco in California was selected because the latitude is relatively similar to Tokyo.

Because the software can calculate only simple shapes, the room that is complex shape, the passage, the loft with inclination ceiling and open ceiling are excluded from the object in the calculation of the index (illuminance) to examine the effect of the daylight use. Here, the targets are Japanese-style room, lavatory and bathroom on the first floor, and dining room and child room on the second floor. The daylight is not calculated on the third floor because of the restriction of the condition of architectural form as mentioned above. Moreover, the adjacent building and the plants in the north garden were assumed because they could be set as a shield on the software.

Next, the plans of design of the midway and final stage plan were input by using easy CAD included in the software (Figure 4 and Figure 5). Concerning the direction, the axis in the north south was matched to north for handiness. On the complex shapes, they were regarded as simple shapes because only the body of basic shape and the part of windows could be input, that is, we did not consider the inclination ceiling, the stairs, the forces and the height of the window. The plants in the north garden the adjacent building and were set as a shield.

Under the condition above, the calculation parameter was set on the screen shown in Figure 6. Although several things such as heat, air-conditioning and the consumption of energy of artificial illumination could be set, here, the next parameters were set on every each room to be calculated from the viewpoint of the daylight use.

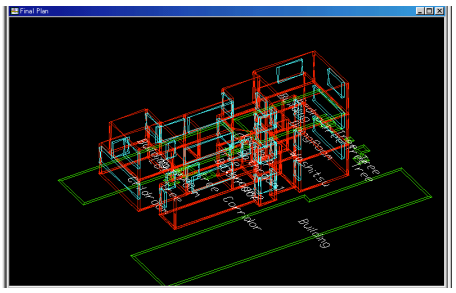


Figure 4 Midway design stage plan by easy CAD.

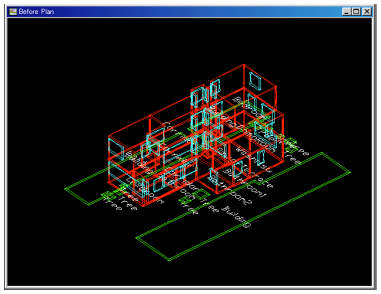


Figure 5 Final design stage plan by easy CAD.

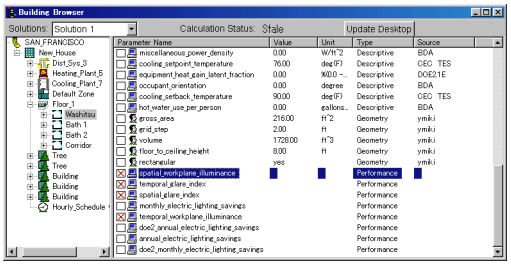


Figure 6 Parameter setting.

- The illuminance distribution of the horizontal (average value in daytime: calculated by the height on the work plane (three feet))
- Change of average illuminance (time and month)

The results are shown below, in which the effect of the daylight use were produced in particular (Figure7-Figure15). On the illuminance distribution of the horizontal and the change of average illuminance of each room, it is possible to examine the effect of the daylight use by comparing the result of the midway design plan with the final design plan.
< Japanese-style room on the first floor > In the final design stage, the part around the room has lightened finally by having added the lighting window in the southwest part. Moreover, sunshine can be secured in the winter. (Figure7 and Figure8) Sunshine cannot be secured because it is the rainy season in around June, replacing with Japan.

< Lavatory on the first floor > In the final design stage, the amount of the lighting increased by having the lavatory facing the courtyard, and the brightness of the room has improved as a whole. (Figure9 and Figure10)

< Bathroom on the first floor > In the final design stage, the amount of the lighting increased by having the bathroom faced to the courtyard as well as the lavatory, and the brightness of the room has rather improved as a whole. In addition, the bathroom is lighted around the bathing time by the peak of sunshine around 18. (Figure11 and Figure12)

< Dining room on the second floor > The tendency is similar to the Japanese room on the first floor. (Figure13 and Figure14)

< Child room on the second floor > In the final design stage, the brightness of the room has improved by increase of the window. (Figure15 and Figure16)

It can be judged that the results of the simulations above mostly support the quantitative evaluation for the final design plan conducted in preceding chapter except the elements that cannot be set as a condition of the simulation such as the effect of the lightshelf.

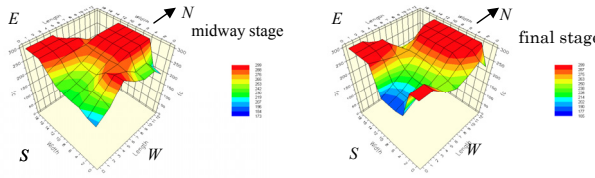


Figure 7 illuminance distribution (horizontal) Japanese-style room on the first floor.

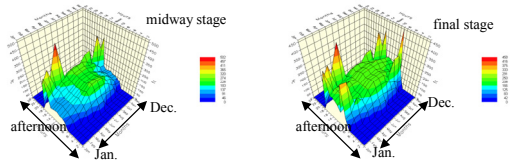


Figure 8 Change of average illuminance Japanese-style room on the first floor.

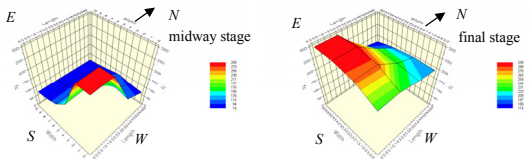


Figure 9 illuminance distribution (horizontal) Lavatory on the first floor.

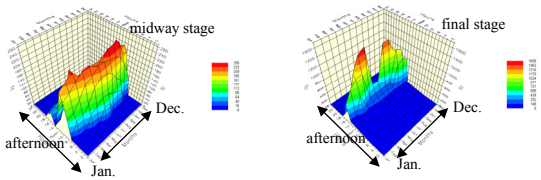
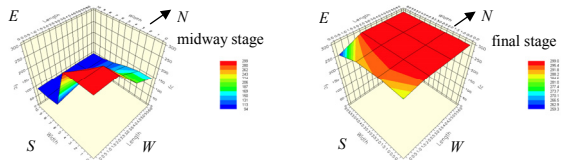


Figure 10 Change of average illuminance Lavatory on the first floor.



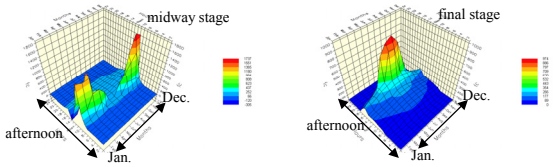
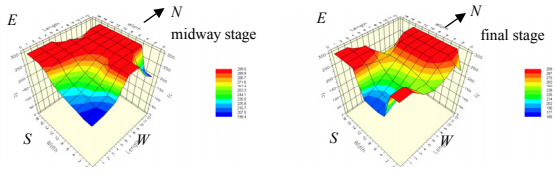


Figure 11 illuminance distribution(horizontal) Bathroom on the first floor.

Figure 12 Change of average illuminance Bathroom on the first floor.



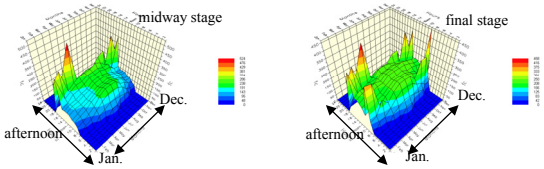
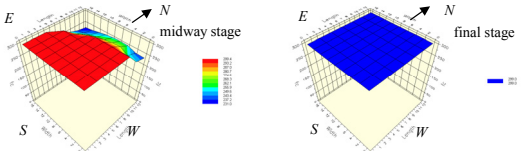


Figure 13 illuminance distribution(horizontal) Dining room on the second floor.

Figure 14 Change of average illuminance Dining room on the second floor.



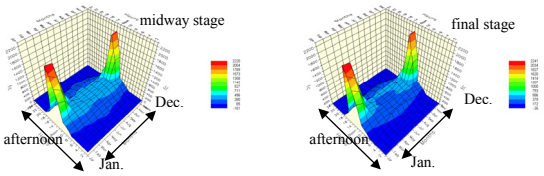


Figure 15 illuminance distribution(horizontal) Child room on the second floor.

Figure 16 Change of average illuminance Child room on the second floor.

4. REQUIREMENTS FOR LUMINANCE ENVIRONMENTAL DESIGN TOOL OF INDEPENDENCE CIRCULATION TYPE WHICH ADJUSTS TO JAPAN

From the result in the preceding chapter, the effectiveness of a simple daylight environment forecast tool that considered the region was shown. However, dense living environment has increased in the city part in Japan, and the application of sunshine lighting system is requested such as use of lightshelf, light duct, mirror and prism. The evaluation tool that can correspond to these devices is necessary. On the other hand, the lighting from the lower side is conducted by reflecting the light in the veranda in the Japanese-style room in Japan. It is necessary to correspond to the daylight use form shown above.

It would be possible to design the laminate environment of the independence circulation type by making the tool that corresponds to the meteorological data of Japan on the basis of the characteristics mentioned above.

5. CONCLUSION

In this research, the qualitative examination concerning the daylight use was actually reflected to the plan in the housing design process. In addition, it was examined what degree of effect there were in the point of daylight use finally with an initial design simulation tool, and it was confirmed that the brightness was improved particularly. As mentioned above, although the software used here is an effective tool in the point that it can consider the various conditions such as a site in spite of its simplicity, in the point of considering the region, it cannot correspond to the situation of Japan because it targets only the climate of the United States. Furthermore, it cannot evaluate the lighting from the lower side such as a Japanese-style room and the lighting tool that is effective in a dense part such as lightduct. From now on, it will be needed to make a daylight simulation tool, which is able to use in earliest design plan that corresponds to the climate of Japan, and to examine the example applied to actual design.

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Testing and Evaluation of LCA and LCC Tools for Buildings

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1. INTRODUCTION

The development of LCA and LCC tools in the building area aims in many cases on the needs of architects, designers or research institutions. In Finland an approach has been chosen, giving special attention to the needs of building developers and housing corporations in the public, private and commercial area. LC Test is an applied research project in Finland. LC Test evaluates international achievements based on customer demands in the construction sector.

The LC Test project is conducted by the Polytechnic School of Engineering, Kuopio, Finland under the auspicious of major players in the Finnish building society. The project is part of the Finnish governmental program BUILDEN and jointly financed by the Ministry of Trade and Industry, Ministry of Environment, the Technology development centre TEKES and a group of commercial and real estate organisations. DHV Accommodation and Real Estate, the Netherlands has been brought into the project for transfer of international experience.

2. LC TEST WORKPROGRAMME

The principal aim of the project is to clarify customer needs and based on this define selection criteria in regard to LCA and LCC tools. With these criteria several LCC and LCA shall be tested and evaluated in order to identify an easy to use tool for calculating the environmental impact of buildings and efficiently guiding decision-making during the building's life cycle.

Aim 1. Charting and specifying the need of the customers

The first aim is the identification of customer needs and the development of selection criteria for the evaluation of LCA and LCC tools. Selection criteria are for example:

- The resource need postulated by the use of the tool
- The easiness and swiftness of the use
- The compatibility to the other software used by the customer
- The implementation field (e.g. the design phase, the phase of the project)

- The energy calculation procedure
- The potential for international use
- The references and usage experience
- The transparency of the results, credibility, comparability and usability
- The total costs of the analyses
- The consideration of the environmental criteria
- Easy program to use
- Suitable for project monitoring
- The LCA and LCC procedures must be separate
- The tool has to be in use outside of the research institute which developed it

Aim 2. Evaluating and testing the tools
During the test phase concrete calculations are performed with a selection of potential LCC and LCA tools in order to evaluate the suitability of the tool towards customer needs and the opportunities for an international application. The buildings, which are chosen for testing, represent typical buildings for a specific customer group (commercial, public and private sector).

Aim 3. The recommendations
Finally the project is expected to result in recommendations about specifications for an easy to use LCA and LCC tool and LCA and LCC calculation procedures for the building projects which are supported by the government. Furthermore the requirements for developing LCA-, LCC tools and data-files for an extensive use shall be evaluated and the decision, whether to further develop existing tools or better create a new tool, shall be prepared. Finally a comprehensive view on benefits from the tools for the customer shall be provided.

Tool evaluation process
The research considered the building, space and system level. Material chains had not been analyzed, but derived form the in the tools embedded databases. The tools that had been tested are LCA and LCC tools used in the European area. About 10 customers' building projects (new developments and renovations projects) in different life-cycle phases (design phase, use phase) had been evaluated. This could experience the tools' compatibility to the building process. The buildings represented the sectors:

- Residential buildings
- Public and Office buildings
- Commercial buildings

Figure 1: Test matrix shows the type of buildings and LCA/ LCC tool applied during testing. Figure 2 shows the evaluation criteria and results of testing.

			LCA tools				LCC tools		
Type of building	**Building**	SAKE energy calculation tool	BEAT 2000 v1.02	Eco-Quantum v1.01	ENVEST v1.0	GreenCalc v2.01	Kiinteistötieto v2000.0.207	Kostenrete-rentiemodel v1.35a	Årskostnads-analyse v2.0
Housing	Niiralan Kulma Oy one-family house		■	■			■	■	■
	YH-Asunnot Oy rowhouse			■			■	■	
	VVO group appartment house		■				■	■	
Public	City of Jyväskylä enlargement of a school building		■		■	■	■		
	PSAMK renovation of a school building						■		
	Senate Properties modification of a building						■		
	City of Tampere office buildiing				■		■		■
Commercial	KESKO Oyj commercial property					■	■		
	SOK commercial property				■		■		

Figure 1: Test matrix

		LCA					LCA & LCC			LCC	
		BEAT 2000	Eco-Quantum	Envest	Green-Calc	Okoprofil	LEGOE	OGIP	TAKE	Kiinteistö-tieto	Kosten ref.model
The structure of the software	Explicit structure	x	x	x	x		ne	ne	x	x	x
	Calculation methods transparent						x	x	x		
	Suitable for new projects and for restoration projects	x	x	x	x	x	x	ne	x	x	
	Suitable for the early stage of planning			x		x	x	x		x	x
	Potentiality to set boundaries of examination	x	x			x	ne	ne			x
	Includes the default values according to building type			x			ne	ne	x	x	x
	Suitable for project monitoring and steering	-	-	-	-	-	x	x		x	x
	Fullfills the methodological requirements of LCA calculation	ne	x	ne		ne	x	x	x	-	-
	Includes sensitivity analysis		x				ne	ne		-	-
	Suitable for estimation of operating and maintenance costs	-	-	-	-	-	x	x		x	x
	Suitable for defining the need for restoration and the renovation costs	-	-	-	-	-	(x)	(x)		x	
Exploitation of the results	Possibility to compare building and component alternatives	x	x	x	x				x	x	x
	Consumption of water and energy detailed	x	x				x	x			x
	Environmental loads detailed	x					x	x	x	-	-
	The results exportable to a spreadsheet	x			x		ne	ne		x	x
	Possibility to customize the presentation of the results		x	x			ne	x		x	

tools selected for in-put phase

no further study

ne = not evaluated

- = criteria not relevant for the type (LCA/LCC) of software tool

(x) = not fully applicable

* = reviewed only by the publicly available information

Figure 2: Evaluation criteria and results

3. RESULTS

From the project it appeared that it is still unclear what LCA tools offers. For most customers the use of LCC tools has priority above LCA tools. The growing interest in LCA tools is implied by the assumption that both tools require comparable input data. Therefore it is important that the effort for data-input, calculation and interpretation is limited.
Actually for most tools the opposite seems to be the case. Often the time needed for data input is exceeding the reasonable accounting time. The efforts for using LCA and LCC tools does not match with the fact that often small companies with limited budget (engineering companies, architect bureaus, installation companies) will be in charge for applying the tools.
Furthermore it had been found that the software used for LCA and LCC tools is not very advanced in regard to software architecture and interface design. User interfaces are often too complicated and not self-explaining. Only one of the tested software tools allowed the import of an own profile.

Regarding the exposition of results and indicators used, LC-test concludes, like other international research projects in this field, that a LCA tool should expose the results on different aggregation levels: one-number indices (ecopoints etc.), impact categories (greenhouse effect, ozone depletion etc.) as well as inventory data (amount of consumptions and emissions)

An important result from the project is that none of the tested tools had been directly suitable for Finland. Customers claim a lack transparency (black box calculation) and criticize that building typologies (at least building descriptions) and environmental profiles are strongly related to national situations. None of the tools allow input of an individual energy mix.

A lack of common codes and universal building descriptions between countries has been identified. The available tools are dominated by the national culture. In order to make tools applicable for the Finish market, modification is needed.

4. CONCLUSION

A prerequisite for the development of LCA and LCC tools is further European and national research with the aim of developing a common framework for building data, building structures and environmental data. Parallel to this harmonization process, the development of profiles is recommended (national profiles, energy profiles, specific supply-chain profiles) which might ease data-input and interpretation. The tool should at least allow the adjustment of an individual energy-mix. But more than this, in order to handle the information flow from manufacturing, design and maintenance, tools should have an open structure. Here lies one of the greatest challenges for the further development of LCC and LCA tools: the development of a Life Cycle Information System,

Developing A Sustainable Urban Form for New Town in North Jordan

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1. INTRODUCTION

Jordan University of Science and Technology campus was designed by the Japanese architect Kenzo Tange in the late seventies, the first stage of University building became operational in 1986. the campus is one of the largest single site in the world, 7.5Km. long and 2.8 km. wide, with ultimate intake of 30,000 students. The government intention, that the area around this site eventually will become a regional growth center in the North of the country.

The planning authorities designated an area of 3 km wide around the campus, to avoid problems of unplanned growth. The campus and site of new town are located in the central area of the north region, 20km east of Irbid. The campus layout is a reflection of the nearby roman town Jerash. The cross-avenues (Cardo-Decumans) form the main distributors for the University buildings, which are designed on the traditional courtyards. The avenue along the width of the comps called social spin, and the avenue along the length called academic spin (Fig.1).

2. OBJECTIVES

2.1 Identifying elements of Sustainability and their bearing effect on the urban form.

2.2 Integration of those elements in the planning and design process of the new town.

3. ELEMENTS OF SUSTAINABILITY

The historical town of Umm El-jimal is located 45km. east of the campus, has been studied to find out how this town survived over 2000 years. The reason for this survival was the surface water collection system. The town depended on complete system made of simple, pipes, channels, wells and reservoirs. The efficiency of this system is dependent on the utilization of landscape topography in such a way that its distribution influenced the town morphology. (Fig. 2).

Learning form the past to build for the future, the sustainable town should work with nature, harvesting rainfall from landscape and urban roofs, disposing of sewage on site, generating electricity form the sun, drawing on local produce for food, and using private transport only for journeys outside the town boundaries.

4. REVIEW OF DEVELOPMENT STUDIES AND PLANS

4.1 Integrated Regional Development Study of North Jordan, March 1980, Japan International Cooperation Agency, Tokyo.

The study proposed four alternatives for Urban growth centers in the region, Decentralized, Mono-centric, Duo-centric and Tri-Centric Patterns. In the four alternatives, the campus is a focal area for growth, but the largest growth was proposed in the Duo-centric pattern and contain two phases, one for (5000) staff members and students of the University, the other is for a population of (30.000).

4.2 Yarmouk New Town, Study and development plans, 1984, faculty of Engineering Team, Yarmouk University, Irbid.

Proposed development on east, south and west sides of the campus (Fig. 3-4) for a population more than (100.000). Neighborhood area size (1km × 1km) form the basic unit for the layouts. Plans are repetitive in their units with long roads, car depended and lacks sustainable elements.

4.3 Development Project for New Town 1996, staff members of Dept. of Architecture, Faculty of Engineering, Jordan University of Science and Technology. IRBID

The plans proposed development on the surrounding areas of the campus for a population more than (200,000). The layout is conventional and prepared according to the planning regulation.

5. PLANNING METHDOLOGY AND SUSTAINBILITY

The negative outcome of conventional urbanization process, are Social, Environmental and Economical Problems, To avoid these, we must look for another alternative, the (Sustainable Urbanization Process), which is defined as natural and man-made environments coexist in harmony to satisfy present generation and to ensure future generation will not have less opportunities.

New method has been adapted for the development plans of AL-Hussin New Town Project, 1999. done by students of urban design, supervisor, A. Al-Azzawi, Dept. of Architecture. (Fig. 5)

The new method mainly consists of the following three stages

5.1 Information and Analysis. Collection of relevant information to form a Data-Base for Decision Supported System (D.S.S).

5.1.1. Site selection for town location. The preservation of agricultural land is a major consideration, as the total area is less than 12% of total land of the country. The land on the east side of the campus was chosen to avoid the better class of land on the west side.

5.1.2. Population. Annual growth rate of (3.4%) will result in population of (2,220,000) for the whole region in the year (2020). It is expected that the town will take about (20%) of the regions population, then the ultimate population of the new town will be (268,000).

5.1.3 Climate. Mediterranean to semi-arid, cold to mild in winter, very hot in summer. Shady narrow streets and courtyards of traditional buildings are appropriate for this climatic conditions. (Fig.2)

5.2. Urban Elements.
Plans with details and charts …etc. for orientation, energy and conservation, water and rain water collection, social fabric, movement and transportation systems, agriculture and crops, community activities, economics and investment, ….etc.

5.3 Assembly and Integration
superimposing the different Urban element plans to integrate the (Urban Matrix), to make sure, that all the individual systems of (5.2) above, will work together to form the overall sustainable system of the Urban form.

The Urban structure of new town is compact, composed of multi-nodal districts like traditional villages to create image of community and preserve the regional architectural characters.

The campus is linked to the new town by extending the social spin to the major Urban center and by boundary roads on north and south sides.

Urban centers are designed in hierarchies of size, density and mixed use, they are linked together by main roads and to the neighborhoods by secondary roads for verity of shopping and services. The residential neighborhoods are surrounded by agricultural lands, to create green belt, preserve low rural scale, and to involve community in growing crops.

Archeological sites and valleys of running surface water are treated as open spaces for recreation. Topography have been developed to form a rain water collection system to irrigate the land, supply the lake, and overcome some of the problems of water shortage in the area and the country in general. Topography and water collection system have influenced the layout of the town, which become more organic, a quality is already observed in Umm El-jimal (Fig. 2).

The good agricultural land on the south-west side is reserved as ecological park.

Sport facilities are located on the north side, for the use of near towns and village of the region, to encourage interaction between the new town and the rest of the region. Industries are located on the south and north sides for access, and to avoid westerly prevailing wind.

6. CONCLUSION
Creation of sustainable Urban form requires the careful study, Analyses and integration of all systems of nature in a new process of development, this operation can be very inventive producing new forms and healthy living environment.

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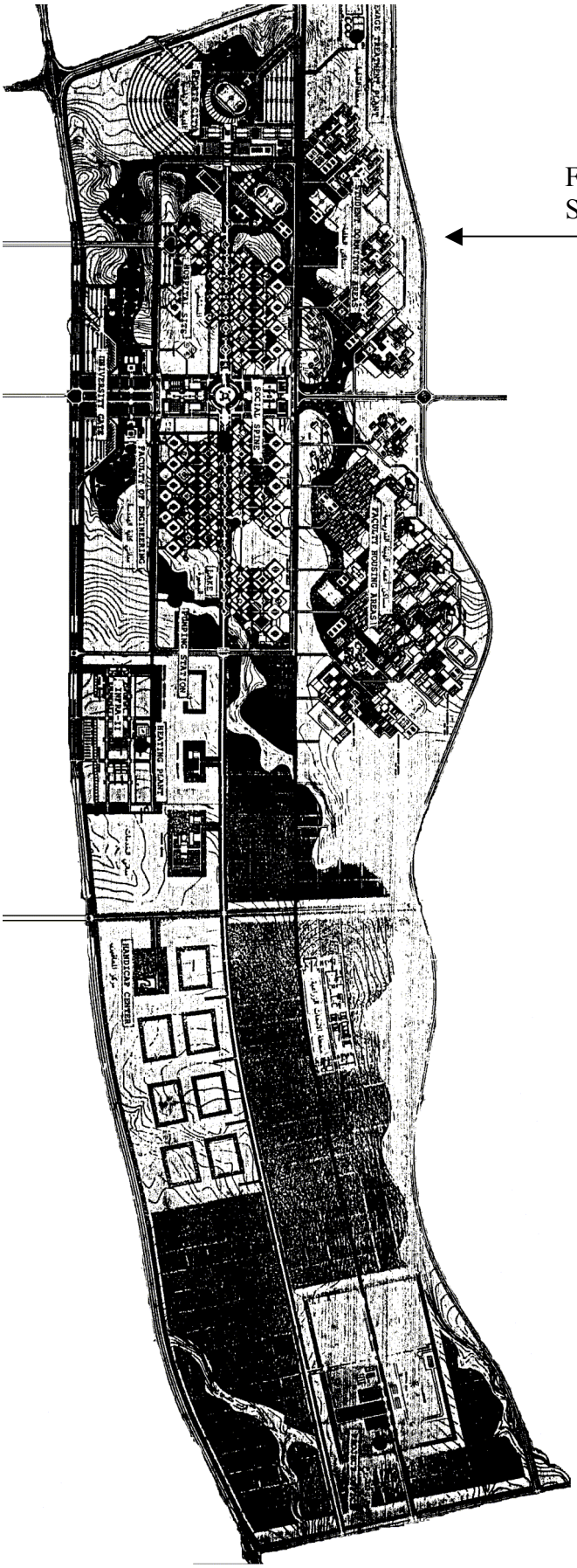

Fig 1: Master Plan Jordan University of Science and Technology.

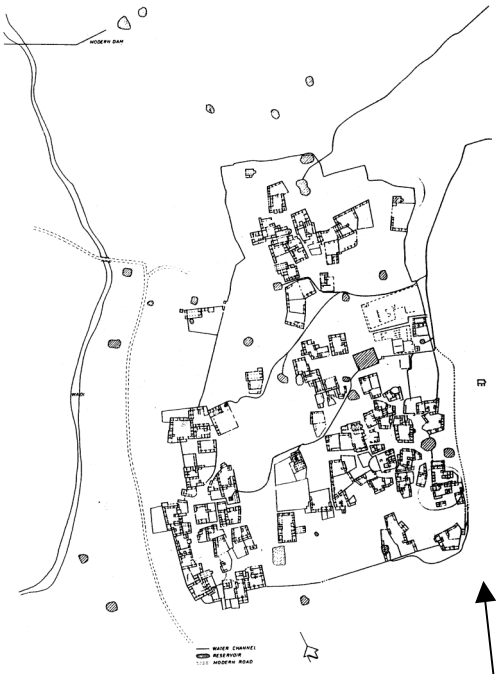

Fig 2: Water Supply system in Umm-Eljmial. Bert Deviries 1978

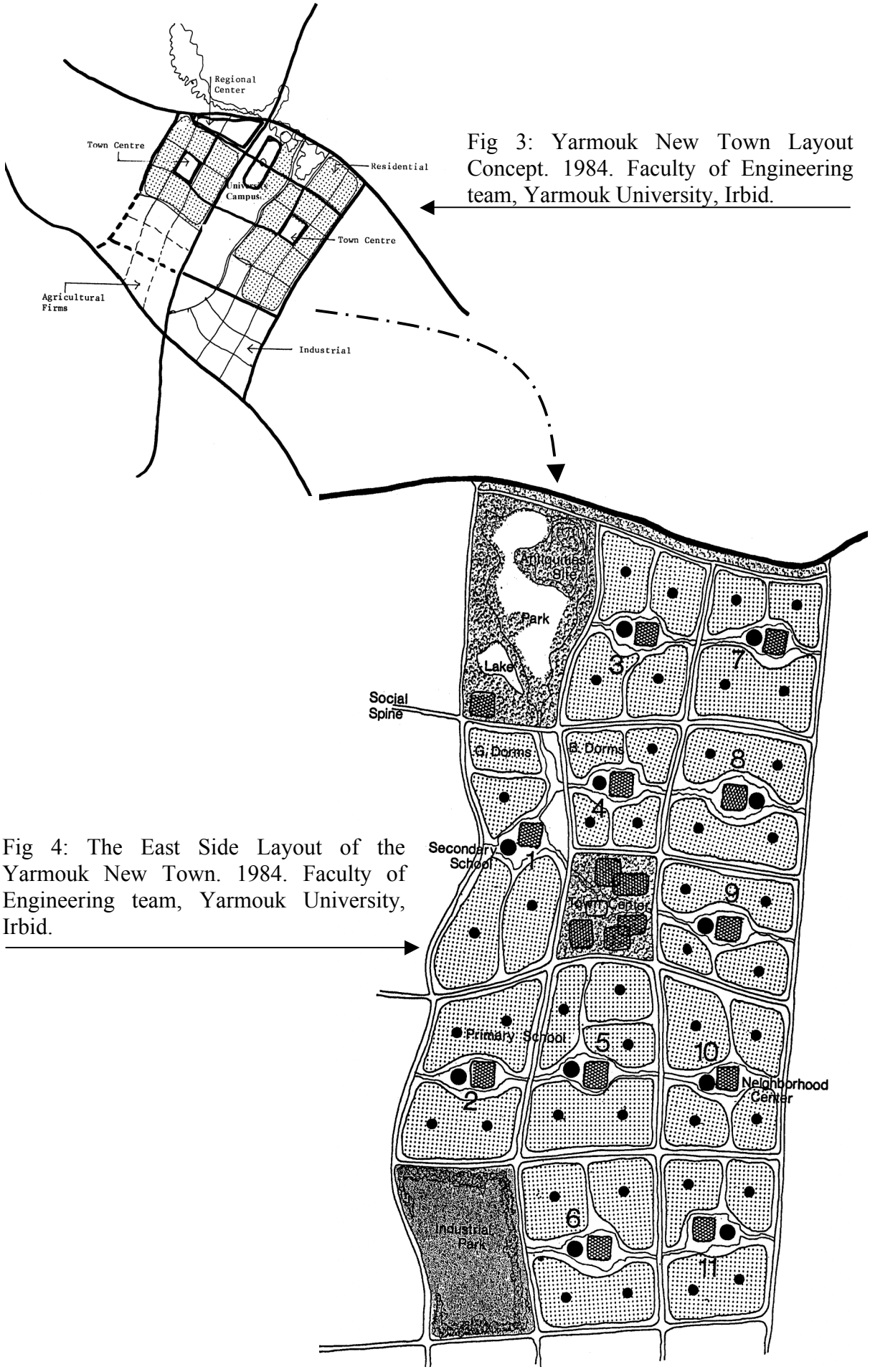

Fig 3: Yarmouk New Town Layout Concept. 1984. Faculty of Engineering team, Yarmouk University, Irbid.

Fig 4: The East Side Layout of the Yarmouk New Town. 1984. Faculty of Engineering team, Yarmouk University, Irbid.

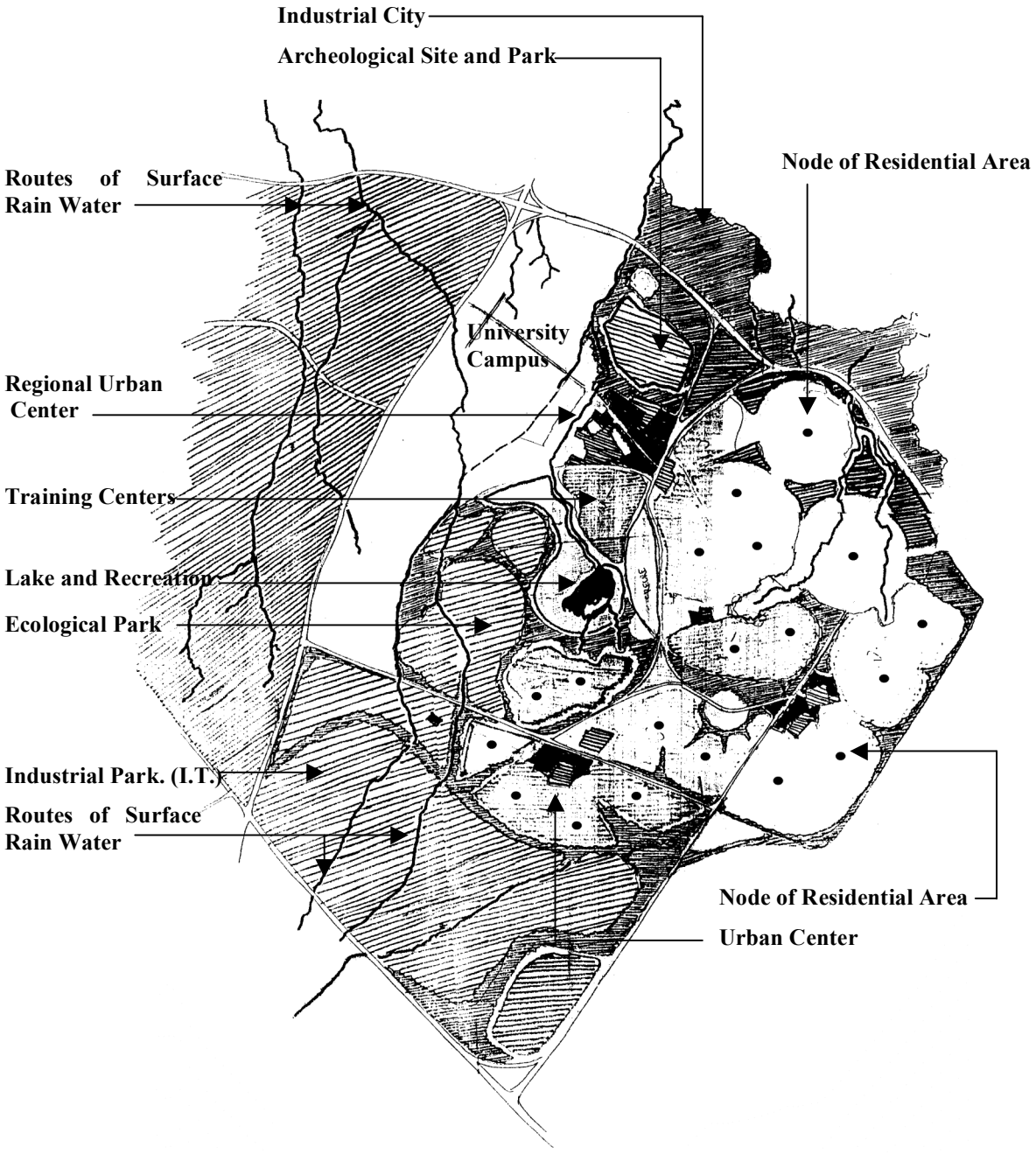

Fig 5: Al-Hussin New Town, Zoning Layout. 1999.

An architect friendly interface for a dynamic building simulation program

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1. ABSTRACT

This paper describes the project ORCA, an architect friendly interface developed by the author, for an existing dynamic simulation program, as part of the research program "META-Design Environment" at the TUD, faculty of Architecture. The program, VA114, was originally developed by the TNO research institute; it is the leading thermal load and overheating risk assessment tool for buildings in the Netherlands.

The interface was developed with the aim of improving the acceptability of the VA114 simulation tool by the architectural profession. The program, originally written for use by HVAC engineers, enables a designer to assess the combined impact of building and HVAC systems upon indoor thermal comfort and energy use.

The assumption underlying the development of ORCA is that thermal comfort and energy use can be optimized most effectively through sensible building design. This assumption leads to the belief that the designer, in this case an architect working on the early stages of building design and indoor climate control, is able to make thermally responsible designs by means other than using extensive HVAC systems.

2. BACKGROUND

The architectural design of a building is of prime importance as to the required level of HVAC and hence related energy consumption in order to allow for good indoor thermal comfort. Building designers often make decisions in the early stages of design which have significant consequences for the building performance. In many cases the building designer (architect) is not aware of these consequences. Not seldom they do not even feel responsibility. To comprehend these consequences and make decisions based on these consequences we need tools that can support the designer in this matter. Scientifically based and internationally validated tools are available being developed by other disciplines they are seldom used by building designers because these tools are not compatible with the designers working methods and needs.

The Meta design environment (MDE) research project targets design support for architects in the early design stages.[1, 2] This project focuses on methods and strategies which facilitate the assessment of the consequences of design decisions by building designers themselves. The Meta design environment aims at facilitating feedback from various disciplines (e.g. building services, construction, management) at the initial design stage. The importance of providing early feedback lies in the far reaching consequences of many decisions taken at this stage,

often on an intuitive bases. It is our belief that the availability of accessible decision support tools at this stage can contribute to a more conscious and better building design.

ORCA is one of the projects that was launched from the META design research project. It aims at improving the acceptance and usability by building designers of an advanced calculation and simulation model in the field of indoor environment and energy use.

3. DESIGN STRATEGY

3.1 Users needs and expectations

Users' needs and expectations are an important part of software development. The need for background information and the detail of input and output parameters restrict the applicability of many advanced calculation and simulation models to the early building design stages. Figure 1 illustrates the position of the domain targeted by ORCA relative to existing tools .

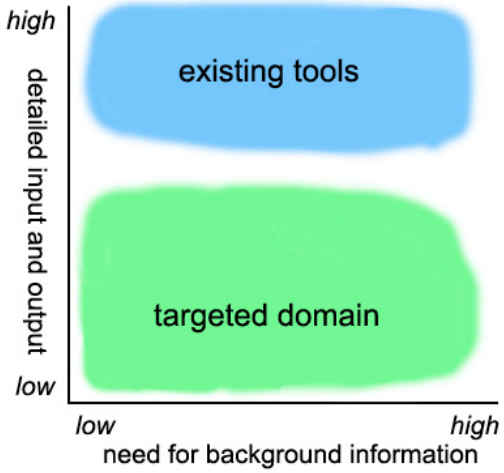

Figure 1: Existing tools and targeted domain

The domain targeted by the ORCA project is diffuse and needs to be specified. Table 1 presents an overview of possible needs and expectations of specific user categories. The table shows that research students, for example, would have a need for highly detailed input and output. On the other hand, design students could use the tool for design support; they would not have a need for very detailed input, and even a lesser need for detailed output.

Table 1: Background and needs of different ORCA users

User categories	Technical background	Demand for reference information	Need for detailed input	Need for detailed output
Building designer	medium	medium	medium	low
Design students	low	high	medium	low
Research students	medium	high	high	high
HVAC consultant	high	low	high	medium

Although building designers were selected to be the primary user group, possibilities for the other user groups were also explored. It is our belief that a more flexible tool that can be used by different user groups can contribute to the communication between these groups.

3.2 VA 114, building simulation

VA114 is the leading building simulation program in the Netherlands. The kernel and interface were developed by TNO and VABI and the program has been subject to improvements over a period of twenty five years. VA114 has been successfully tested according to the international BESTEST methods [2]. In the Netherlands VA114 is mostly used by HVAC consultants for the overheating risk assessment. The number of companies using the program exceeds 150, which represents a consultants market penetration of approximately 80%.

VA114 is a dynamic multi zone simulation model for overheating risk assessment, which simulates the interaction between building, HVAC installation and environment. Using hourly climate data such as temperatures, sunlight angles, sunlight intensities and air velocities VA114 can simulate one ore more rooms within a building during a specified period.

Some of the input categories within VA114 are:

- Room geometries
- Physical properties of building materials
- Physical properties of glazing
- Internal heat loads (per hour of the day)
- HVAC methods and properties

After a simulation run VA114 returns a set of output data which can be tailored to the users specifications. The output data gives information on:

- Hourly, daily and monthly indoor temperatures
- Hourly energy use for ventilation, heating and cooling.
- Radian temperatures
- Overheating risk assessment

3.3 Interface and kernel communication

In the ORCA project, the kernel of VA114 has been approached as a ‘black box’. Figure 2 describes how the interface and the kernel communicate. The interface generates a series of ASCII based input files that describe the input model. When the kernel is activated it reads these input files, executes the simulation and generates the calculation results in a series of ASCII based output files. The output files can then be translated by the interface and presented to the user.

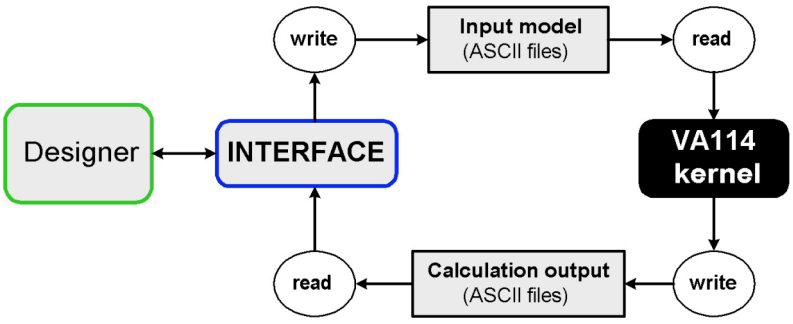

Figure 2: Design setup using kernel as ‘black box’

The user interface and the calculation kernel are completely separated. The manner in which each item is translated from the interface to the calculation kernel is key to the applicability of

a complex calculation model to early design situations, when little detailed information is available.

The interface can be developed according to the user's needs and expectations (table 1). The approach to the interface design was based on two interacting aspects. On one hand the interface was functionally designed to meet the needs and expectations of the user (building designer). On the other hand the interface was technically designed to translate user input into an input model (ASCII files), while maintaining a valid calculation model for the kernel.

3.4 Translation of interface input into input model

The importance of the translation step is underscored by the requirement that only a limited amount of the detailed information needed for the calculations should be input by the user. The remaining data have to be either provided as default values or generated by ORCA. For the ORCA project all the input items in the input files were examined and categorized based on accessibility criteria: inaccessible by the user (defaults), directly accessible (via the interface), and indirectly generated through calculations and libraries.

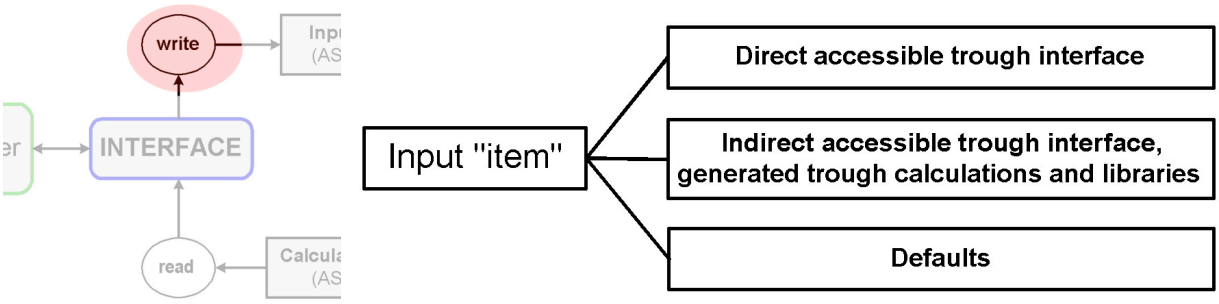

Figure 3: Input item criteria

Using the criteria shown in figure 3 it is possible to tailor the interface according to the users needs. With every selection that is made trough these three criteria, with regard to the interface design and programming, it should be checked whether the input model is not compromised, and if the data that is entered in the interface matches with the input model.

3.5 Translation of calculation results

The interface reads, translates and presents calculation results (Figure 4). It is built up so as to allow the user to compare information from two successive calculation runs, thus allowing feedback on possible effects of design changes on energy use and thermal comfort.

The output files of VA114 consist of text and numbers. The intended usage of ORCA asks for a more graphical output. It is not as much the exact numbers that are of interest, but the overall performance and the ability to quickly compare calculation results for different design alternatives.

3.6 User and interface interaction

The interface design and the underlying cognitive ergonomics are the foundation for the acceptance and usability of the tool by a user. Although this applies to software interfaces in general, the cognitive ergonomics are of such importance that they deserve mention as a vital part of the ORCA project. The issues that concern user and interface interaction, e.g. constancy, predictability and constraint propagations are thoroughly discussed in a separate report [3].

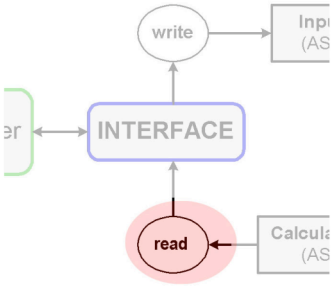

Figure 4: Output translation

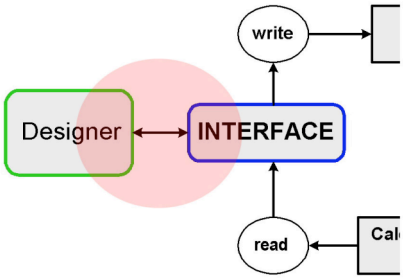

Figure 5: User and interface interaction

3.7 Information availability

The availability of information on the program and on the various topics addressed in the calculation proved to be essential. Although the interface is designed for use by building designers it is still necessary for the user to have a certain amount of knowledge in order to make sensible use of the tool.

It is not possible to predict which knowledge is available with a single user and which is not. Making all the information directly available in the interface would compromise its usability. The solution for the ORCA project was the introduction of a separate 'help-file' presenting information about the program itself and on various building and HVAC design topics.

The help file is presented in a common internet setup (html), for easy access and flexibility to meet different users' needs (see table 1, need for reference information). An internet based structure also offers compatibility with other applications and flexibility for updates and maintenance.

4. RESULTS

The ORCA project produced a fully functional tool called ORCA. The first version of the program was developed for students. However, the flexibility in the data exchange with the kernel and the presence of an extensive 'help file' makes it possible to support different types of users. ORCA will at first be implemented at the faculty of Architecture in the Delft University of Technology.

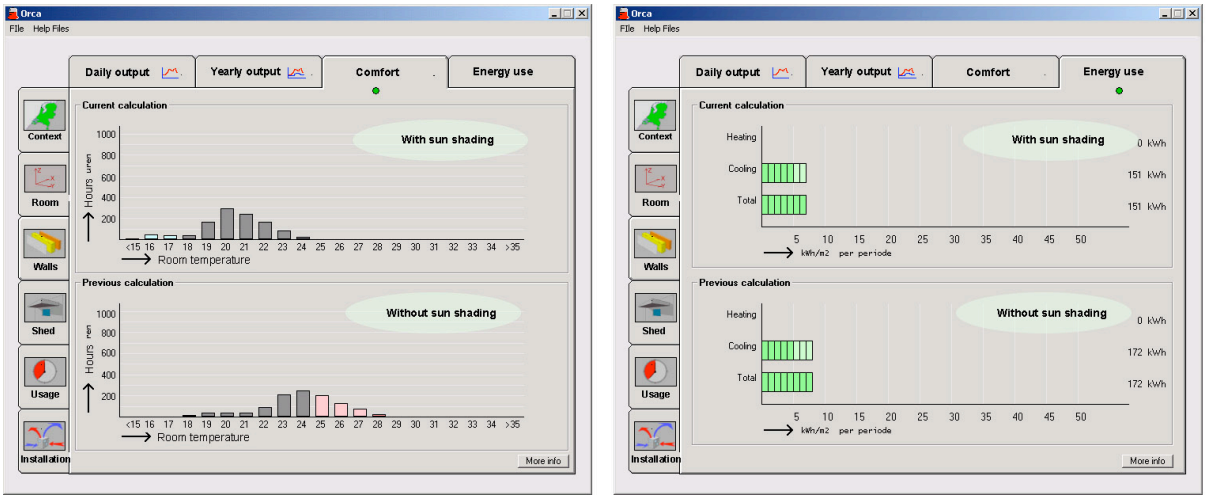

Figure 6: ORCA output, comfort and energy use

4.1 Principles

The ORCA interface is divided into two sections, identified by a set of tabs on the left hand side for input data and one at the top for output data. This enables a user to switch from input to output and back, changing one item at the time. The four output tabs present the user with results from the current and previous calculations. This is intended to provide a quick feedback on design changes.

Throughout the interface, links to the 'help file' are presented as buttons. When a button is clicked, information on that specific input or output item is displayed.

4.2 Example

An example is described to illustrate the potential of ORCA. We entered data for a standard office room with one southward façade, equipped with mechanical ventilation and cooling. For the opening in the façade, we first entered double glazing *with* sun shading and secondly double glazing *without* sun shading. The calculations were made for a summer period.

Figure 6 illustrates two output tabs, one for comfort and one for energy use. The output shows that the introduction of sun shading has a positive effect on the indoor comfort and on the energy use for cooling.

5. CONCLUSIONS

An architect friendly interface (ORCA) was developed for an existing dynamic simulation program, VA114. The purpose of the interface is to:

- Assist building designers in improving their insight into general principles of indoor environment and energy use in buildings;
- Provide timely feedback to building designers regarding possible effects of their early design decisions on energy use and indoor thermal comfort
- Facilitate discussion with HVAC and energy specialists.

The interface was functionally designed to meet the needs and expectations of different users (students, designers and consultants); to this end, it is provided with an extensive 'help file'. Technically, it was designed to translate user input into an ASCII based input model, while maintaining a valid calculation model for the kernel. This translation is key to the applicability of a complex calculation model to early design situations, when little detailed information is available.

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Investigation of the Barriers to Sustainable Building in China

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1. INTRODUCTION

In China the Policies dealing with ecological issues have shifted in recent years from the advocacy of environmental conservation to the achievement of sustainable development. The government declared that they pay attention to how to protect the ecological environment and insist that they have a sustainable development strategy[11]. They would do their best to deal with the relationship between economic development, population increasing, resource utility, and environment conservation[11].

The Chinese construction industry's challenge is to produce buildings to meet the needs of 1.3 billion people in a rapidly blooming economy. There is no doubt that sustainability is very important for the development of the Chinese construction industry. As a significant contributor to the national economy, the Chinese construction industry contributes about 6% to the annual GDP[14]. With the rapid growth of a free market economy, the Chinese construction industry developed very quickly and was radically transformed. However, the Chinese construction firms are largely judged by their profitability[8], and they usually ignore the protection of the building environment[2].

Under these circumstances, the emergent problem is that, in theory the Chinese government regards sustainable development as an essential strategy for national economic development, but in practice, the construction industry and other industries are still continuously contributing to the pollution of the natural environment[2]. The situation is serious[2]. In order to uncover the dynamics that affect the development of sustainable building in China, we investigated the barriers to sustainable development in the Chinese construction industry.

This paper focuses on the gap between policy and practice of sustainable building in terms of the following question, i.e., which are the primary barriers for Chinese building professionals to carry out sustainable building idea. Our data was obtained through a literature review, site visits and a questionnaire survey of a random sample of clients and consultants in the industry, which included questions about sustainable environment barriers in Chinese construction industry.

2. SUSTAINABLE BUILDING AND THE CHINESE CONSTRUCTION INDUSTRY

The concept of "sustainable building" defined as "the notion of designing, constructing, and operating buildings and landscapes in a manner that minimizes environmental impacts. It incorporates energy efficiency, water conservation, waste minimization, pollution prevention, resource-efficient materials, and indoor air quality in all phases of a building life "[9]. At present sustainable building is becoming a global issue. As a part of China's transition to a market economy, the Chinese construction industry has been going through continual changes in a process of reform to make it more effective. To bring about the huge increases in per

capita GDP identified under the Ninth Five-year- plan and Long-term-target for the year 2010 requires enormous expansion of the infrastructure, in particular water conservancy, energy and transportation. In addition, the construction industry is required to focus on the construction of urban and rural residences and public projects[13]. In order to respond to such huge demands, the Chinese construction industry has had to become better managed, more mechanised and establish stricter quality control systems. The industry has focused on increasing its efficiency by strengthening management, updating plants and equipments, shortening construction times, improving quality, increasing returns on investment, and introducing a tendering system[7].

During the process, pollution and hazards caused by urban civil construction projects have become a serious problem in China. Sources of pollution and hazards from construction sites include e.g. dust, harmful gases, noise, blazing lights, solid and liquid wastes, and messy sites[10]. These types of pollution and hazards can not only harm residents nearby, but also affect the health and well being of people in the entire city. As far as we known, most of the construction firms are updating the new technologies and management methods, but their awareness of the environment issues is scarce.

3. BARRIERS TO SUSTAINABLE BUILDING

We have identified 8 barrier clusters, which described below:

(1) Lack of Access to Financing for Costs Needed to Design and Implement

There are many difficulties and challenges ahead for implementing environment management in the Chinese construction industry. The most important one is that efforts spent in environmental protection do not necessarily result in lower project costs and duration. Instead sustainable methods are often more expensive than traditional ways of building and traditional building materials. In fact, introducing environmental management into construction management increases projects' direct costs, since to date contractors do not need pay for the pollution and hazards generated by their projects. Due to the introduction of market mechanisms and project management approaches in the late of 1980's, most Chinese construction project teams more and more care about project costs, duration and quality[8]. In most cases they do not incorporate environment conservation issues into their own responsibilities[2].

(2) Lack of Education or Training in Sustainable Design and Construction

In China, sustainable building is still quite a new concept. Most architects and engineers have never been educated in sustainable building issues during their professional schooling. For the designer, the greatest barrier is the lack of understanding of the need for sustainable design, and for the project team members, the greatest barrier is the lack of technical understanding of sustainable methods.

(3) Lack of Expressed Interest from Clients

Although sustainable buildings are designed to meet certain objectives and provide benefits such as using energy and products more efficiently to produce significant financial savings and a high return on investment and other aspects, the clients have not been interested in any sustainable features except for energy efficient heat which could lead to an immediate payback. The clients who decide on the adoption of sustainable building methods, and who have to bear the costs are often not the client who benefit from sustainable methods. The

asymmetric distribution of costs and benefits is an important barrier to the diffusion of sustainable building development in Chinese construction industry[2].

(4) Lagging of the Technique for Design and Construction

There is a large gap, which exists in energy saving and environment protection between the Chinese construction industry and western construction industry. The traditional construction technique is adopted in China, so the consumption of energy and raw material is large. From the statistical data, the consumption of energy and raw materials is about 3 to 9 times more than in developed countries per quarter[15]. For instance, clay-brick is widely used in China, especially in rural areas. Due to the producing of clay-brick, about 6,700 ha of land is destroyed every year in China[6].

(5) Lack of Establishment of Regulation and Administration

For the Chinese construction industry, there is no specialised organisation for promoting sustainable building. Among 500,000 Chinese construction companies there are only three large-size enterprises which have obtained ISO14001EMS certifications[7]. The regulation about environment protection in the construction industry is limited. Although there is a general environmental regulation, the environmental regulation especially in the construction industry is still a blank in China. The policy about environment is not coordinated to other policies, and there is no practice for it. At the same time the general environmental protection regulation is too inane and insufficient to the building practice in China. In other ways, the monitoring measures are absent according to the environmental regulation.

(6) Lack of Awareness of the General Public

The awareness of environment protection among the general public in China is low compared with that in many developed countries. People seem to be too busy in accumulating personal wealth to worry about the natural environment. In recent years, many Chinese people invested in new apartments and decorating their new apartments by using many new materials. They always were involved in assessing how to make the indoor environment beautiful and comfortable but did not pay enough attention to consider whether the materials affect health. Many interior projects adopt some building materials harm to health and the natural environment[10].

(7) Weak Institutional Link in China's Administrative Structure

China's enormous size and complexity makes it difficult to obtain a holistic picture of it. Institutions at the local level must report to their parent institutions within the system. Within this reporting system there is inadequate coordination among institutions within villages and even provinces[2]. The administrative structure is a short obstacle to efficient environmental policy implementation in China. The weak institutional links make an overall environment protection strategy within a locality or province very difficult[2]. The lack of motivation to implement sustainable building policies is also affected by the lack of central control and coordination in enforcing strict standards throughout China. The lack of horizontal linkages between central government and local governments leads to overlap and uncoordinated efforts in pollution control and natural resource management efforts at the local level.

Achieving an overall environmental protection strategy within a locality or province is very difficult. Lots of small size enterprises exist now in China, e.g. rural enterprises. Environment management for them is very difficult[2]. Furthermore, the economic reforms led to an explosion of small-scale industries that do not adhere to pollution emission standards[2]. These

industries are hard to regulate because of the prevalent bribes they give to evade environmental regulations[2].

(8) Immature of Environmental Protection Industry

Referring to the statistics from China's Environment Protection Ministry, the output of the Chinese environment protection industry is about RMB60 billion[13]. There are millions of environmental production manufactures in China, but the development of the industry is unbalanced and is mostly concentrated on two areas: one is the producing of the environmental protection products; another is the utilising of waste materials. Due to non-mutual of natural/ecological protection market in China, the technological service for environmental protection is weak. The market of natural ecological production has not been set up, and the social service is very slow. The structure of the environmental protection products is unbalanced. Most products are about changes the pollution of water and gas, and the equipments of sold waste, but environment measures are limited[13].

4. CAUSES OF THE BARRIES

Different barriers result from different aspects of sustainable building. To suggest the strategies for lowering those barriers, we have looked at the dynamics in the building process that affects the development of sustainable building in China.

4.1 Policy - Implementation Gap

Construction industry activities have a large impact on the environment. But currently in China the policy about environmental issues for the construction industry is a blank[7]. There is an implementation gap leading to a lower level development of sustainable building in China. Particularly, how political and economic changes in China have affected the implementation of environmental and energy policies.

Stricter implementation of environmental regulations would force highly polluting and generally more inefficient plants to shut down or, in the course of cleaning up, the more energy efficient they could become. Thus, it is a key issue for the development of Chinese sustainable building to make practical policies[10].

It is also necessary for the Chinese government to improve the scientific and technical level in the regulations, apart from setting up strategical regulations. This includes two aspects: technology guideline and economic control, e.g. to set up a set of new operable standards, including the quantified ones for sustainable design in China.

4.2 Organisation

In the Chinese construction industry, there is no special system (market mechanism) to work for promoting sustainable building. Barriers two, five and seven are caused by this problem.

4.2.1 Constraints and Limitations of Organisation Structure. The decentralized power structure resulted in some impacts on environmental issue along with Chinese economic reforms. At the central level, government has paid great attention to the environment issues arising from the population growth and economic development. But local government officials often put environmental protection to a lower priority than money making opportunity[2]. Lack of central control and coordination in enforcing strict environmental standards throughout China caused a lack of motivation to implement expensive environmental protection policies.

For the Chinese construction industry, presently they have no capacity to effectively monitor pollution emissions, sustainable design and implement controls[7].

4.2.2 Inefficient Legal System and Administration. At the same time due to the economic reforms, the re-organisation and re-construction of legal and administrative system occurred. The chaos during the process also lead to a damage to reach the environmental goals.

4.3 Technologies

The lack of technologies refers to different aspects including technology of design and construction, technology of environmental protection industry, and so on. For environmental technology, more work should be conducted to promote technology innovation transfer from western/developed countries to China. In addition, although there are few quantitative/benchmark standards and operational measurements for sustainable building, it is necessary to develop a unique system for the Chinese construction industry by referring to other developed and developing countries.

4.4 Financial Capability

China is a developing country, although the economy developed very fast in the past 20 years, so there are no adequate financial capabilities to invest in environment protection. On the other hand, after gradual reforms over two decades, the Chinese economy is still on the way of shifting from planning system to free market economy. With the maturing of a free market, the real link among sustainable building and tax system, enterprise profits will has to be established step by step. Then, it will play an important role that a set of reward and punishment mechanism for enterprises to manipulate sustainable building based on free market system.

5. CONCLUSION AND FURTHER WORK

There is an implementation gap between policy and practice of sustainable building in China. The barriers of the Chinese construction industry obviously exist, and damaged the implementation of sustainable building policies in China. Actually, the practice of sustainable building in China is still quite new. That is no doubt that the transfer from the black road of speedy industrial into a green road of sustainable development will be a long and very difficult process, especially for China, a country facing the double pressure that comes from developing the economy and protecting the environment. The problem resolution would not only rely on the production methods and technologies, but also has to be relevant to the economy, culture, sciences and technologies, society, administration and value opinion, and so on.

Based on a comparative analysis, we may recognize some of the barriers in the Chinese construction industry are the same as in the other countries, like in Sweden. To address these issues, we would be able to find an opportunity to promote sustainable building as a technical innovation transfer from western/developed countries, e.g. from Sweden to China. On the other hand, some barriers are unique. In order to solve these problems, it is necessary for us to understand and analyse those barriers deeply in the context of Chinese construction industry. In the further we will do some research on the strategies for developing sustainable building in Chinese construction industry corresponding to conquer barriers. On the next step, we plan to establish a set of index system to evaluate sustainable building in China and do some case studies.

6. ACKNOWLEDGEMENT

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International Cooperative Research and Development on Sustainable Urban Management by Conversion of Buildings Part 1: Research Concept

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1. INTRODUCTION

In Japan, the vacancy rates of office buildings have been at high in big cities since 1992. This problem is especially acute in Tokyo, where it is estimated that over 2.27 million square meters of office floor area will be oversupplied in 2003: big urban redevelopment projects will be completed in 2003 [1)]. It is likely that the rents of these new offices will be affordable for excellent companies so that they can relocate from present offices and this situation will lead a chain of relocations from the lower grade offices to the higher ones. As a result, the number of buildings that are virtually impossible to let will increase in Tokyo, just like other cities in Japan. Under these circumstances, this research aims to regenerate urban areas by conversion —changing the use of buildings— especially by converting redundant offices into flats, although instances of conversion are still very few in Japan. In order to achieve this aim, the following problems have been identified.

1) Facilitation of conversion projects; it is necessary to define requirements to generalize conversions in city centers.
2) Attaining diversity in residences in urban area; conversions should contribute to create comfortable urban residences.
3) Development of new technologies for rehabilitation works; conversion projects are expected to ensure equivalent quality of new buildings at half cost, or a higher quality at equivalent cost.

This paper intends to introduce the scope of our research. Since schemes of conversion are undeveloped in Japan, it is necessary to take a holistic approach to the matter. At present, our research group is organizing four subcommittees and investigating following 4 themes.

2. THEMES OF SUBCOMMITTEES

2.1 Research on the Actual Conditions of Urban Offices

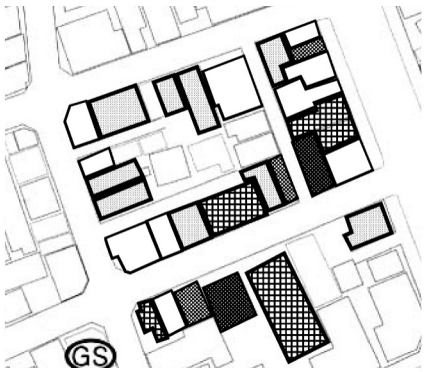
Subcommittee#1 is assigned to grasp the actual conditions of urban office buildings and building owners in Tokyo and Osaka by gathering statistics and carrying out field surveys. This research has two aims.

The first aim is to reveal the distribution of vacant offices and the rent gaps in city centers. The field surveys have been carried out already at three areas including Chuo-ku, Minato-ku, and Chiyoda-ku in Tokyo, and have reached the following findings.

1) Thirty percent of the buildings in these areas suffer from over twenty percent vacant floor rate.
2) Fifty five percent of these buildings were constructed in 1980s, and twenty three percent before 1980.
3) The rent gaps between office buildings and residential buildings can be seen at six areas in Chuo-ku and at four areas in Minato-ku. It is likely that the conversion market exists in these ten areas at least [2)].

Table 1 The rent gap between flats and offices in Tokyo

		Averages rent of Office (1,000 Yen/3.3m^2)			
		10 – 13	13 –15	15 – 17	17 -
Averages rent of flats (1,000 Yen/3.3m^2)	No Trade		Hamamatsucho Shibakoen	Muromachi/Honcho Toranomon/Kouman	Nihonbashi /Ginza Yaesu/Kyobashi
	10 – 13	Horidomecho/Harumi Higashinihonbashi Ningyocho/kakigaracho Tsukishima/kachidoki			
	13 – 15	Kayabacho/Hachobori Shinkawa/Shintomicho Akashicho/Tsukiji/Mita Shibaura/Kaigan/Shiba		Shinbashi	
	15 – 17				
	17 –		Roppongi/Nishiazabu	Akasaka	Aoyama



Iwamotocyo, Chiyoda-ku

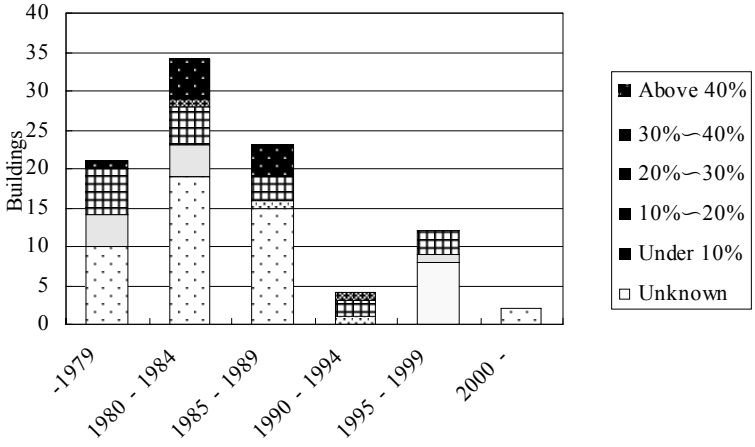


Figure 1 An example of field survey areas and vacant floor rate in Tokyo

The second aim is to identify the characteristics of vacant offices, which include building age, floor area, arrangement of core space and the type of façade. It is necessary to measure the conditions of existing buildings when building owners consider the conversion of their buildings. It seems that the existing methods can be applied to measure the structural performance of a building, since these methods established to check seismic safety can verify the structural performance holistically.

However, there is no method that can evaluate potential for conversion. In order to verify the usable floor area rate for residences, the feasibility of plumbing for gravity drainage, the constraints to ventilation, the means of two ways escape, etc., subcommittee#1 carries out case studies of conversion of vacant offices. These case studies will contribute to establish methods evaluating potential of existing buildings.

2.2 Study on Legal and Real Estate Assessments

Subcommittee#2 studies issues related to legal and real estate assessments. This study consists of three fields: legal, real estate and investment.

The first is to clarify the legal constraints to conversion, therefore is concerned with Civil Law Act, Real Estate Registration Law, Law for Unit Ownership, Etc. of Building, Land Lease and House Lease Law, City Planning Law, Building Standard Law and Fire Service Law.

It has been confirmed already that there are no constraints concerned with Real Estate Registration Law (although it requires the change of the registration after conversion), and City Planning Law. However, some criteria are incompatible with Building Standard Law and Fire Service Law if the use of the building is changed from offices to flats. Typical incompatibilities between offices and flats are shown in Table 2. If the buildings do not satisfy criteria for flats, the cost of renovation works for conversion will increase.

Table 2 Examples of incompatibility in converting offices into flats on Building Standard Law and Fire Service Law

* Office buildings whose floor area is below 1.5 thousand square meters locating in secondary fire zone will not satisfy the fire resistive construction, which is required by Building Standard Law.
* Office buildings whose upper floor area of “fire escaping floor” is below 4 hundred square meters will not secure the two ways escape root in the upper of “fire escaping floor”.
* Habitable rooms without effective window area for lightening will appear.
* Equipment for fire fighting must be increased.

The second is to establish a means to assess the value of converted buildings. There are three kinds of appraisal approach: cost, market comparison and income. The market comparison approach, which is used generally to assess real estates in Japan, is unsuitable for converted buildings, because it assesses the present value based on the past value. It is necessary to use the income approach which assesses the present value based on future cash

flow, since the use of buildings are changed.
However the income approach depends partially on the market comparison approach. It is difficult to practice income approach for converted buildings in Japan where instances of conversion are very few. Subcommittee#2 has defined practical problems of this approach and is trying to establish a new appraisal concerning typical conditions of properties in Japan.

These studies inevitably accompany examinations into the legal implications for Unit Ownership of Building and Land Lease and House Lease Law. It is especially important to examine the latter in conversion projects. This law was revised to secure the right of residents against owners during the Second World War and prevented an economical usage of urban space. However Land Lease and House Lease Law has been revised in 1991 and 1999, and leasehold has been founded. The combination with leasehold can be an effective alternative for conversion schemes.

The third is to evaluate a project system as a real estate investment platform. Forty five percent of building owners, who own a building in central Tokyo, are private owners or small companies [3)]. They are likely to have a problem acquiring capital for conversion, but prefer to keep their ownership rather than selling their building. Under these circumstances, it is important to encourage them by developing effective schemes for conversion.

2.3 Research on Overseas Conversion Trends

Subcommittee#3 is carrying out the research on visions and methods for town planning that involve conversions. The difficulty of this study is that we cannot have a concrete image of conversion within Japan. Investigation of overseas examples is the first step to understand the contribution of conversion toward regenerating urban space. Subcommittee#3 has researched five cities, which are listed in Table 3 [4)].

Table 3 Visiting list on the inquiry of conversion

City	Date	Conversions/Respondents
Milano	December 4th – 9th, 2001	Five buildings/A residents
Sydney	February 4th – 9th, 2002	Eight buildings including two under constructions/Two developers, Three architects, A building manager, A contractor, Three residents
Chicago	March 13th – 18th, 2002	Ten buildings including two under constructions/A city officer, A developer, Two architects, A building manager, Two residents
London	March 18th – 23rd, 2002	Five buildings/Two contractor, Four developers
Zurich	March 21st – 31st, 2002	Eight buildings/Three architects

According to a well-known conversion architect in Chicago, who has done ninety-two conversion works since he started conversion seventeen years ago, there were two major difficulties in early works. The first was financial difficulty. Few banks were willing to loan to conversion projects because their judgment depended on past instances. However, their attitude started to change about ten years ago, he said. The second was incompatibilities with building code. Typical problem was the lighting. The building code of Chicago required locating windows within bedrooms. However, bedrooms with no windows often resulted from the conversion of warehouses. These rooms with no windows were not permitted to be called a “bedroom” in the advertisement. This constraint resulted in a handicap of sales.

Chicago City, however, has derestricted the building code to support conversions from offices or warehouses into flats in late 1990's. In Chicago City, the vacancy rate of buildings in downtown was over twenty percent constantly and revenue from real estate tax had been decreasing. It seems that such condition enforced the city to make change.

Cities with similar situations have been found through surveys of subcommitte#3. Derestricting building code or funding grants will encourage changing the use of buildings. More details of this survey will be introduced in other papers.

2.4 Development of Technological Sub-Systems

Subcommittee#4 explores the possibility of developing new project models and sub-systems for converting offices into flats. It is necessary since construction technologies in Japan have been optimized for new constructions.

The necessary sub-systems have been specified with respect to Japanese context: flooring system improving sound insulation, high performance cladding system, and forced drainage piping system. For example, forced drainage, which is generally used in Europe, requires new development in Japan: the discharge of drainage is more common in Japan because of its particular life style, especially the way of taking bath. More details of such examination will be introduced in Part 2 of the research.

3. CONCLUSION

This paper has shown the concept and scope of the research, together with part of our current results. This research will be carried out from 2001 to 2003. At the end of the research, we will propose practical methods and political suggestions for conversion in Japan.

While large-scale suburban residential areas around cities have emerged in the 20th century, the number of residents has decreased in many urban centers in the world. This tendency can also be seen in Japan. However, today, recovery of the number of residents in obsolete areas of city centers is required in order to regenerate cities. The regeneration of city centers as a residential area will be achieved more effectively in Japan, if the conversion is accepted as a method of improving urban environment.

4. AKNOWLEDGMENTS

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5. NOTE

[1)] This estimate is notified by Mori Trust Co., Ltd. http://www.mori-trust.co.jp/press/

[2)] Rents of flats references publications by Recruit Co., Ltd., and rents of offices by Ikoma Data Service System Co., Ltd.

[3)] This analysis is based on the database of STB Research Institute, which collects information on real estate registrations, covering seventy-five of office floor area in Chuo-ku and Minato-ku.

[4)] We appreciate following coordinators and respondents on these surveys. F.Bucci, Politecamco di (Milano); M.Marosszeky, The University of New South Wales (Sydney); Y.S.Choi, Loebl Schlossman & Hackl and P.Fitzgerald, FitzGerald Associates Architects

(Chicago); D.Gann, Sussex University (London); Y.R.Kataoka, PSA Publishers (Zurich).

The right building in the right place

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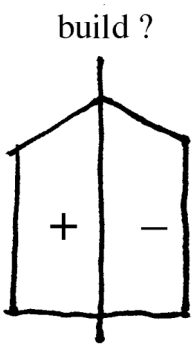
Summary:
Sustainable buildings are beautiful, strong and made of good materials.
Sustainable, invisible architecture has integral quality, a healthy climate inside the building, is intelligent, flexible in use and repairable.
Sustainable is everything that future generations like to inherit, use and maintain

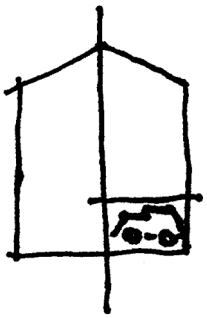
Integral Design

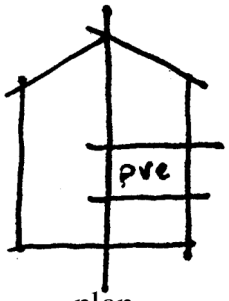


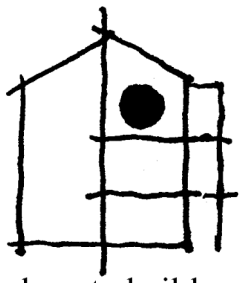
The right building in the right place: an objective we are all aimimg for. Architecture should be holistic and ecological, to be accomplished by the integral designing of a building in its environment, which can resist the ravages of time. The integral designing of a building starts at the sun and ends in the magma far beneath the building's foundations.
(see illustration 1)
The definition of sustainability is, in my opinion, short and simple: "everything that future generations like to inherit, use and are able to maintain is sustainable"; this may refer to buildings, roads or an optimal infrastructure, but it will be more probable refer to its opposite; the intact, vacant land.
By the way (let's not forget this)
"Ecology is the part of biology that examines the relations between organisms (human beings) and the environment".
Leaving undone – not doing things, not building is often of great quality.
I would like to draw your attention to five related aspects:
1) to build or not to build
2) where to build?
3) what to build?
4) how to build?
5) integral designing, its added value

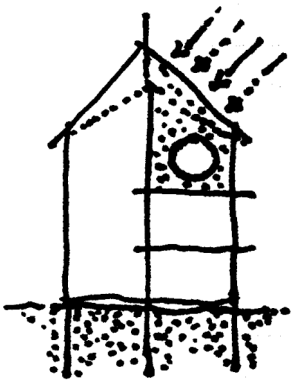
(illustration 1)











(illustration 2)

The first aspect the most important question is: should we or should we not **build ?**
Generally people in poor countries make better use of the earth than people in rich countries, who think it unfair to leave things undone, to be unable to pay for things. Refraining from building– based on knowing better, that is the subject to be considered. Town councils never ask if a new building is necessary. Once you have paid your fees you will receive a building permit. Building is an economic activity. Suppose an official of the Building Control Department will ask you: Cannot you organize your company better or cooperate with another company? Reconstruct or improve buildings-Re-use is the word!

The second aspect is **where** to build. We can consider this in a wide context.
Maybe we had done better to build in one of the former colonies, for example, in Surinam or in the centre of Turkey or of Morocco than in Amsterdam Bijlmer without a metro. Within the Netherlands, however, accessibility by means of good public transport is of primary importance, as well as a thetatre and a hospital next to the NS railway or bus station.
Our belief in the private car has appeared to be much greater than in any other collective transport.

The third aspect is: **what** should we build?
Sustainable is what future generations like to inherit, can use and are able to maintain. Many monuments vital to the townscape were on the list to be pulled down because they were not functional. Later a new fitting function was found for them.
A building should be flexible in construction,lay-out and use, and be of ample size so that new functions can be installed in the building. A beautiful building that is liked and well-kept will become a protected monument in the long run. Beauty is the first condition for sustainability. Long-term social acceptance is also important.

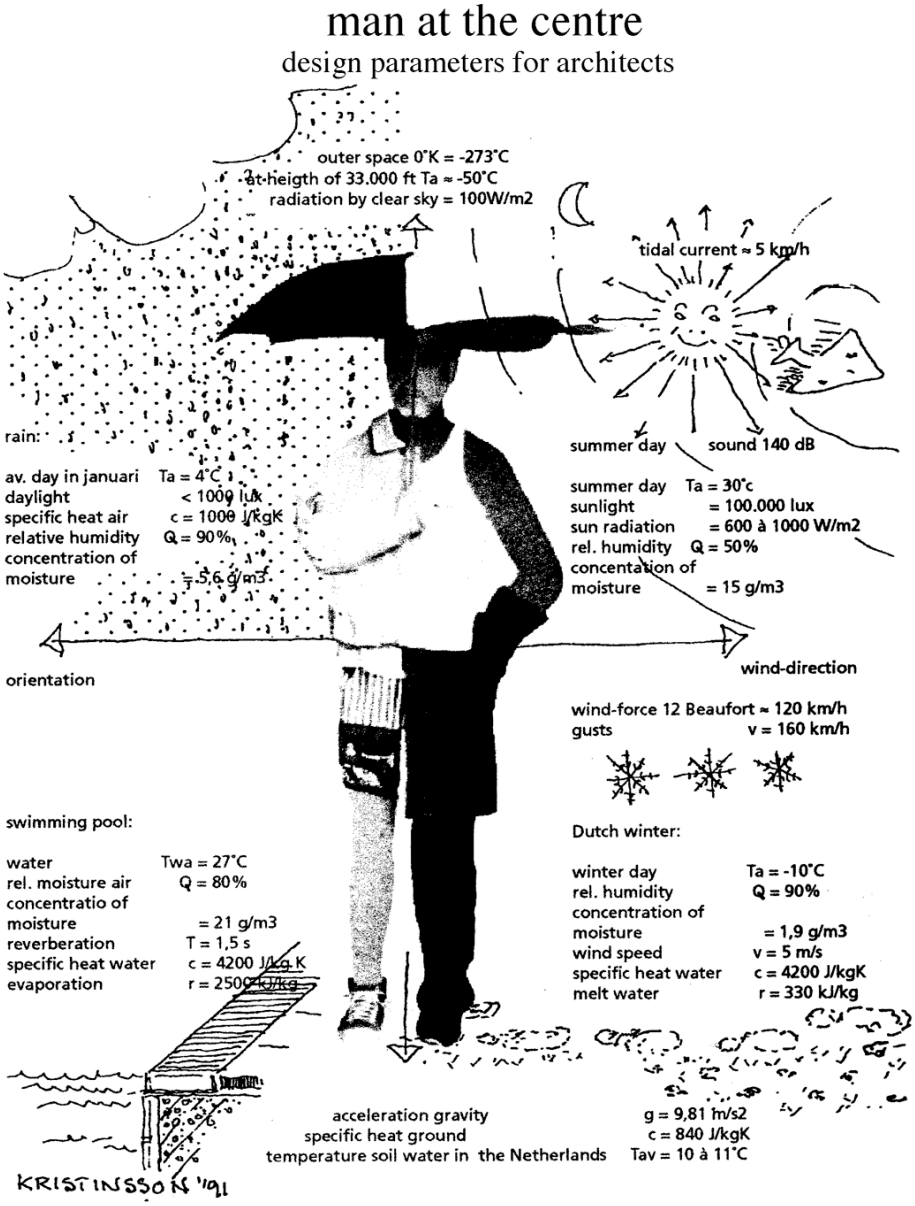
The fourth aspect: how we should build is according to most people the core question. We know everything about building. In all kinds of educational institutes up to and including technical universities it is part of the curriculum. All kinds of government organisations, public utilities and whatever othet organisations there may be, keep themselves occupied with legislation, levies, preparations, executing and checking building activities.

The fifth aspect is the **integral design** of buildings.
The sustainable added value, which definition is nowhere to be found, is for outsiders often another invisible quality. Only the experienced camper appears to put up his tent in the right place. According to integral designing a building starts at the sun and ends with the geothermal conditions above the fluid magna of the earth. (see illustration 2)

This means taking into account: the place on the earth, the seasons, the orientation towards the sun, the highly effective daylight, overheating by sunshine and the radiation during the night, the clouds and the minimum and maximum precipitation, the minimum and maximum air temperatures, the wind and the compass card of the location, all soil conditions including ground level, height profiles, surface water, groundwater level, groundwater flow, groundwater age, soil composition and pressure resistance, the specific temperature of the soil, the groundwater temperature, the aquifer, the geothermic conditions and the risk of earthquakes.

This list is far from being complete, but already confusing. We had better try to visualize this mass of data as design index numbers. The designers are in need of clear designing tools for buildings in different seasons and the related extreme climate conditions.

(see illustration 3)



(illustration 3)

In conclusion, are the sustainability aspects of a building measurable? And can they be expressed in physical units?
The answer is yes, apart from some exceptional cases, for example beauty is very difficult to measure. Beauty is closely related to time, place, culture and personal taste.

A building's useful life expressed in years
The minimum useful life expectancy of a building can be expressed in years, that is its occupation and costs determine the writing-off period.
The shorter the period of writing-off is in years, the more imortant dismantling will be with re-use of parts and components of the building.
An effort is made to determine the various types of buildings in a price/quality ratio to the building price in €/m2 or €/m3 with a design parameter of finishing levels and installation complexity.

The sustainable right building in the right place exceeds all wtiting-off periods. People love these buildings, they can use them well and keep them in good repair. They will be proclaimed monuments as cultural landmarks.

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The Effect of Alternative Materials on the Recycling Potential and Total Energy Need

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1. INTRODUCTION

Both low energy houses and recycling have become important research fields in order to minimise the environmental impact from the building sector.

Numerous studies have showed that operation accounts for the main part, about 85-95%, of the energy use in the general run of dwellings.

The energy needed for operation can be considerably decreased by improved insulation of the building envelope, technical solutions etc. These measures will increase energy use for the production phase. Studies of low energy houses have shown that the energy for production can account for as much as 40-60% of the total energy use Nielsen 1995, Winter 1999, Thormark 2002. Studies have also shown that even if the energy for operation was very low in one building, the total energy use (energy for production, maintenance and operation) in that building over 50 years was actually higher than in a building which had a higher energy need for operation Feist, 1996.

Therefore, the more the energy needed for operation decreases, the more important it is to pay attention both to the energy for material production and to the aspects of the recycling potential. The recycling potential, earlier presented in for example Thormark, 2000a,b, can be briefly defined as the potential for environmental benefits from recycling building materials after refurbishment or deconstruction.

This paper presents values of the energy use for production and operation, as well as the recycling potential and the effects of using alternative materials, for the most energy efficient building in Sweden today.

2. AIM OF THE STUDY

The aim of this study was to investigate the scope for decreasing the total energy need by use of alternative building materials in a low-energy dwelling (45kWh/m^2) in Sweden. The energy for operation, the embodied energy, and the recycling potential of the original building was previously presented in Thormark, 2002.

3. METHOD

The alternative constructions of the building were designed in order to minimise the embodied energy. The constructions were redesigned without changing of the U-value. For the redesigned constructions, the total energy need over the life cycle as well as the recycling potential was calculated and compared with the values for the original building.

The processes included in the life cycle were; manufacture of building materials, transport to the

building site, maintenance, and operation. Energy for erection and demolition was not included. The lifetime was assumed to be 50 years in order to facilitate comparison of the result with other studies. Maintenance intervals were based on the maintenance code of municipal housing companies SABO, 1998. Maintenance for each material was calculated as embodied energy times interval/50. Heat exchanger, ventilation terminals, adhesives, seals, fittings such as nails and screws and a few minor components were not included. The amount of spill during erection, estimated by the contractor, was included.

The energy for operation was obtained from Wall, 2000. It was calculated using a dynamic computer program DEROB-LTH, version 99.01. The indoor temperature in the dwelling was set to a minimum of 20C.

It was assumed that all end use energy for operation was produced in a combined power and district heating plant (50% electricity, 50% heat) with an efficiency of 85% and a distribution loss of 7% for both heat and electricity. A general pre-combustion (the energy need for fuel production) of 4% was assumed for all used fuels.

The embodied energy represents the energy consumed in all phases from extraction of the raw material until it is ready to be delivered from the manufacturer. It also includes the feedstock, the upper calorific value of the material. The majority data were from about 1995, mainly representing production in Sweden and Denmark.

The recycling potential, R_{pot}, is a way to express how much of all embodied energy and natural resources used in a building or a building element could, through recycling, be made useable after demolition. R_{pot} for a building can be calculated as

$$R_{pot} = \sum_{i=1}^{n} EE_i \cdot \text{Remaining lifetime}_i - E_{rec.proc\ i} \quad (1)$$

where

EE embodied energy of the material for which the recycled product will be a substitute .
i = material number
n = total number of materials

Remaining lifetime is the remaining lifetime of the recycled material, as a percentage of the predicted lifetime of the material for which the recycled material will be a substitute .

$E_{rec.proc}$ is the energy used for all recycling and upgrading processes, including additional energy use for the disassembly needed to make future recycling or reuse possible, as well as transport.

Recycling was subdivided into reuse, material recycling, and combustion with energy recovery. Different possibilities of recycling building materials, and the proportions suitable for reuse, are described earlier Thormark, 1997 and will not be dealt with here. It should be pointed out that the forms of recycling or the recycling rates do not represent the general practice of today's recycling, but all techniques have been practised with good result.

The recycling potential was calculated for two scenarios; Maximum material recycling/combustion and Maximum reuse. Each component and its integral material parts were assessed for the possibility of recycling. In the scenario *Maximum material recycling*, a maximum rate of material recycling or combustion was applied. It was assumed that all the materials from a demolition, which can be sorted, would be recycled. In the scenario *Reuse*, a maximum rate of reuse was applied. Sorted materials not suitable for reuse were assumed to go for material recycling or combustion. The scenarios are described in Thormark, 2002.

4. STUDIED OBJECT

The studied object is the Swedish scheme within the CEPHEUS project (cost efficient passive houses as European standard, project number BU/0127/97) in the European Thermie-programme. The housing consists of twenty apartments in four two-storey rows. Each apartment has a net residential floor area of 120 m^2. The buildings were completed in 2001, in Gothenburg, Sweden. The energy annually needed for operation (heating, hot water, household electricity and electricity for fans and pumps) is estimated at 45 kWh/m^2. Measuring of the energy for operation is ongoing. The main construction, except for the insulation standard, is common for Swedish conditions. As the buildings were under construction when the presented study started, the final performance might differ in its details.

The low energy needed for operation was mainly achieved by thick insulation, solar collectors on the roof for hot water production, and an air heat exchanger with an efficiency of approximately 86%.

One thing that makes the buildings interesting is that the low energy needed for operation is achieved by very simple means, which could be applied to any residential building. Therefore, when the options for redesigning the constructions were considered, only simple measures with resource efficient components and less energy intensive materials were regarded appropriate.

In the alternative design, 170 mm mineral wool + 220 mm EPS (expanded polystyrene) in the walls were exchanged to 400 mm cellulose fibre. In the roof, 450 mm mineral wool was exchanged to cellulose fibre. Under the foundation slab, 250 mm EPS, were substituted with expanded perlite. (Perlite is a volcanic glass that when heated to a point in its softening range, expands from four to twenty times its original volume.) In the redesigned constructions, some additional construction materials/increased thickness of insulation were required. Data on embodied energy for substituting materials were collected from [Krogh, 2001].

5. RESULTS

All results are presented per m^2 residential floor area. The energy need for production and operation and the recycling potential are presented in Table 1. In the alternative design of the building, the embodied energy only accounted for about 34% of the total energy use over 50 years compared to about 40% in the original design. However, the *amount* of embodied energy was reduced about 23%.

The recycling potential, in percentage of the embodied energy over a lifetime of 50 years, increased about 5-7% in the recycling scenarios.

The Net use of energy, i.e. total energy use over a lifetime of 50 years less the recycling potential, decreased about 9%. The reductions in energy use were achieved through the use of less energy intensive materials.

The maintenance accounted in the alternative design for as much as 18% of the total embodied energy.

Table 1: Energy for production, operation, and the recycling potential (rounded numbers) for the original and the redesigned building in the scenario Material recycling/combustion.

Process	**Original building**	**Redesigned building**	**Change**		
	(MJ/m2 floor area)	(kWh/m2 floor area)	(MJ/m2 floor area)	*%*	
Production,	*2 045*	*7 330*	*1 570*	*5 650*	*- 23%*

total 50 years					
Material, new building	1 620	5 830	1 180	4 240	- 27%
Spillage	130	480	100	370	- 23%
Transport to building site	45	160	50	170	+ 6%
Maintenance	240	870	240	870	0
Operation, total 50 years (primary)	*3 050*	*10 990*	*3 050*	*10 990*	*0*
Operation, total 50 years (end use)	*2 280*	*8 200*	*2 280*	*8 200*	*0*
Space heating (primary)/ year	5	18	5	18	0
Hot water(end use)/ year	13	47	13	47	0
Electricity, household (end use)/ year	23	84	23	84	0
Electricity, pumps and fans/ year	5	18	5	18	0
Total energy for Operation and production over 50 years (primary)	*5 090*	*18 315*	4 620	16 635	- 9
Rec. Pot, Mat.Rec/ Incineration	*710*	*2 565*	*640*	*2 300*	*-10*
Rec.Pot , Reuse	*820*	*2 960*	*745*	*2 675*	*-10*
Net use, scenario Mat.Rec./comb.	*4 365*	*15 715*	*4 040*	*14 535*	*- 9*
Net use, scenario Reuse	*4 255*	*15 325*	*3 935*	*14 160*	*- 9*

Figure 2. Embodied energy and Net energy for the whole building and for the redesigned building parts. Embodied energy is subdivided on energy for initial materials, spillage and materials for renovation. 'Net' is all embodied energy less the recycling potential.

6. DISCUSSION

Two main factors may influence the result of this kind of studies; the quality of embodied energy data and the calculation of the energy need for heating. However, in this study, the influence is assessed to be of no significant. The data quality for the exchanged materials and for the alternative materials, appear to be similar and of an acceptable quality. The energy for heating was calculated only for the original construction, using a dynamic calculation method. The change of insulation materials, however, will have an irrelevant effect on the energy for operation, as all the U-values were kept constant.

Thermal bridges and air tightness are important issues for the energy for heating. Thermal bridges are presumably reduced in the alternative design. To achieve appropriate air tightness, precision is required in the practical execution of the constructions.

The study was limited to the aspect of energy use. However, recycling can also reduce the use of natural resources and the need of space for landfill. In addition, recycling can have negative environmental impacts such as noise, dust generation, vibrations etc 17. Consequently, in future studies of the recycling potential, aspects other than energy ought to be included.

7. CONCLUSION

It can be concluded, that in order to reduce the total energy use in buildings, it is of great importance not only to reduce the energy for operation but also to pay attention to the building materials as well as including recycling aspects in the design phase of new buildings. Further, it is important to express embodied energy and recycling potential as well as energy for operation, not only in percent of the total energy need, but also in terms of MJ/m^2 floor area.

The predominant part, about 85%, of the potential energy salvage can be achieved through maximum material recycling and combustion. The most important measure in order to facilitate future recycling is the use of recyclable materials and to avoid constructions, which are difficult to disassemble, or in which the materials contaminate each other.

The importance of maintenance should not be neglected. Many of those materials/components have today a rather short maintenance interval. Prolonging the lifetime or choosing materials with less embodied energy can considerably reduce the impact from maintenance.

ACKNOWLEDGEMENT

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Ecosystem Services as Criteria for Green Building Assessment

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1.0 INTRODUCTION

In the discussion of environmental architecture, we are conjoining two disciplines, that of architecture, and that of ecology. At their best, green buildings are examples of applied ecology, in that the impacts of architecture are considered from an environmental perspective. To do this, designers must understand the constitution, organization and structure of ecosystems. By utilizing the concepts, methods, and language of ecology designers can create architecture to intentionally engage the ecology of the site.

As we begin to recognize the impact of built environments on natural environments, the question of our assessment methods becomes more critical. Internationally, assessments of our impact on the environment traditionally are based in quantifying the negative impacts on the environment. These indexes are useful for showing, and perhaps reducing the rate of our environmental impacts. However, they lack an ecologically derived baseline, and therefore the ability to assess environmentally sustainable development.

We depend on the services of the environments ecosystems to provide clean water, to regulate our climate, to regulate droughts and floods, for the detoxification and decomposition of wastes, for the generation and preservation of soils, and for the production of other ecosystem goods (i.e. biomass). There is general agreement amongst the environmental community that our built environment is having a substantial negative impact on the natural environment. We are severely compromising the ability of our earth to provide adequate environmental services; we are producing polluted water and air more quickly than they can be cleaned, using materials more quickly than they are generated, and consuming both our natural capital and our income.

While population growth remains the primary leverage point to rectify the disparity between the earth's carrying capacity and our consumption of resources, there is a growing consensus that we can utilize two "design" methods to bring sustainable development within our reach. First, we need to decouple our consumption of energy and resources from economic growth, and secondly, we need to restore our degraded environmental systems so they can once again provide the environmental services on which we depend. This implies a building assessment method that not only identifies negative impacts, but also contains the provision for acknowledging beneficial environmental impacts, such as regenerating the production of environmental services. This paper describes such a method, and also posits an ecologically derived baseline to assess building sustainability.

2.0 RATIONAL

2.1 Capacity analysis as a baseline for sustainability

The earth has finite material resources and biophysical capacity. Humans require the services that are provided by ecosystems. Because of these limits, we must live within the carrying capacity of the earth. As we exceed the carrying capacity of the earth's ecosystems, over time they are stressed, then go into decline, and finally collapse. They are expended rather than renewed. The survival of life on earth, including the human species may be jeopardized (Figure1).

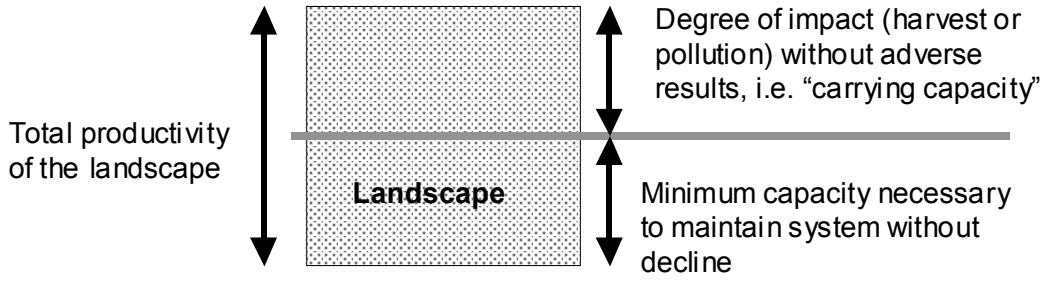

Figure1: Landscape productivity and carrying capacity

We can measure the carrying capacity of a given site, and measure the quantity of various services provided by ecosystems. Similarly, we can ascertain our consumption of resources (in this case specifically the production and operation of buildings) and calculate the degree of environmental impact. By comparing these two metrics (ecological resources and building impacts) we can make rational assessments of the environmental impacts of buildings.

In this context, two basic questions determine sustainability. First, what quantities of ecosystem services are consumed in the production and operation of a given building? This assessment can be measured in (ecosystem productivity) * (acres) / (year). Second, how much land is assigned to the project? Almost any project is sustainable given enough land and ecological resources. *The index of building sustainability (IBS) therefore is the fraction of carrying capacity of the project's land that is consumed in the construction and operation of the building*. An assessment of 1 would exactly meet the carrying capacity of a site, .5 would use ½ of the available site ecosystem services, and assessment of 1.5 would exceed the carrying capacity of the site, and therefore not contribute to the overall sustainability of the earth (Figure 2). *The index of efficiency in sustainability (IES) is there for the ratio of land area to building area at a sustainability index of 1.*

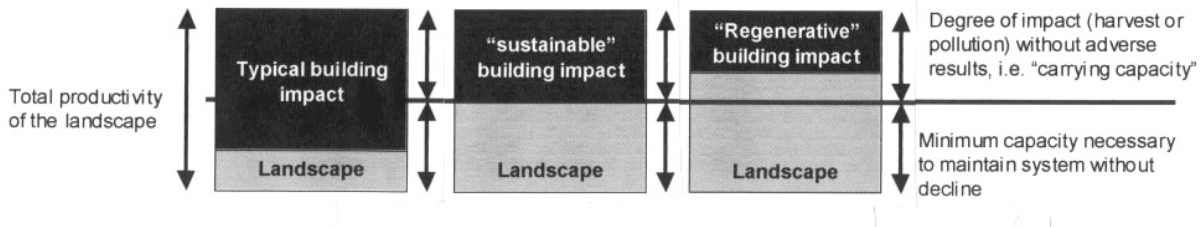

Figure 2: Sustainability indices of 1.5, 1, and .5 respectively

From a demand perspective, building impacts can be reduced through careful design and selections of materials to increase the ecological efficiency (IES) of the product. On the supply side, it is also possible to use the construction of a building as the opportunity to rebuild ecosystems, increase the ecological productivity of the site, and increase the index of building sustainability (IBS).

The establishment of assessment criteria is critical because it defines of building design criteria. Establishing criteria that are based on our best scientific understanding of environmental sustainability will encourage development of building stock that is truly sustainable.

2.2. The Concept of Ecosystems Services

> *" In amnesiac revelry is also easy to overlook the services that ecosystems provide humanity. They enrich the soil and create the very air we breathe. Without these amenities, the remaining tenure of the human race would be nasty and brief. The life-sustaining matrix is built of green plants with legions of microorganisms and mostly small, of obscure animals - in other words, weeds and bugs. Such organisms support the world with efficiency because they are so diverse, allowing them to divide labor and swarmed over every square meter of the earth's surface. They run the world precisely as we would wish it to be run, because humanity evolved within living communities and our bodily functions are finely adjusted to the idiosyncratic environment already created." The Diversity of Life, EO Wilson*

Ecosystem functions are properties of ecosystems. Ecosystems goods and services are the benefits we derive from the different functions of ecosystems. In this paper I refer to ecosystems goods (such as food, biomass and medicines) and services (such as climate regulation or waste assimilation) all as ecosystems services. Ecosystems services are critical to the functioning of the earth's life-support systems, they contribute to human welfare both directly and indirectly (Figure 3). Virtually all of our human endeavors depend on ecosystems services to some degree. If we destroy the ecological niche that we live in, we will destroy ourselves as well.

Gas regulation	Water regulation	Soil formation	Pollination	Food Production
Climate regulation	Water supply	Nutrient cycling	Biological control	Raw Materials
Disturbance regulation	Erosion and sedimentation control	Waste treatment	Refugia	Genetic resources

Figure 3: Ecosystem goods, services and functions: i.e. the benefits of ecological systems

2.0 ASSESSMENT FRAMEWORK

3.1 The intact ecosystem.

Consider a healthy, intact ecosystem. It has a foundational structure of geology, a layer of underground and surface hydrology, a specific climate with quantities of humidity, temperature, sunshine, air qualities and movement, and a fragile layer of biotic life consisting of five kingdoms: bacteria, protist, fungi, plants and animals. Energy flows into and out of the ecosystem, moving and transforming, and the physical materials of the ecosystem are endlessly cycled. These entities interact in intricate ways, natural forces shaping the earth, and energy flows creating nutrient cycles (food webs) in the biotic world.

Over time, ecosystems evolve, becoming more diverse and complex, with high levels of biodiversity. Various relationships develop; predator /prey, symbiosis, interdependencies, and so forth. Specialized ecological niches develop nested inside secondary or tertiary ecosystems.

Biotic life creates structural order in the environment, fighting entropy. As ecosystems develop they become more stable and resilient to impacts.

The biotic world provides the bulk of the ecosystem services. Autotrophs (plants) fix solar energy and serve as primary producers of embodied energy and biomass. Hydrological cycles, carbon cycles, nitrogen and phosphorous are all moderated by ecosystems for optimal habitation. Soil is built, gasses regulated, waste is assimilated, raw materials and foods are produced, habitats created, etc. Ecosystems have a metabolism, and a given capacity for the production of ecosystem services (rain forests, oceans, deserts). We require these ecosystem services for our survival, and to maintain a sustainable planet we must not harvest them more rapidly or in larger quantities than they can be restored.

3.2 Establishing ecosystem capacity

A given ecosystem can be understood as a compilation of the various resources and forces acting on it. Often times an ecosystem has a critical keystone element whose removal drastically changes the characteristics of the system (example: sea otters / urchins / kelp). Other times the capacity of an ecosystem is limited by some biophysical factor such as water, nitrogen, or sunshine. Augmenting the limiting factor can greatly change the ecosystem capacity. Because different ecosystems have differing capacities to produce given products and services, we must identify our needs before we can determine the ecosystems ability to provide for them. For example, a softwood forest may be able to produce the lumber required for framing a small house in two acres. Waste assimilation may require ¼ acre, and carbon sequestration 5 acres. Food production may require 3 acres, and energy production 4, and so forth (Figure 4).

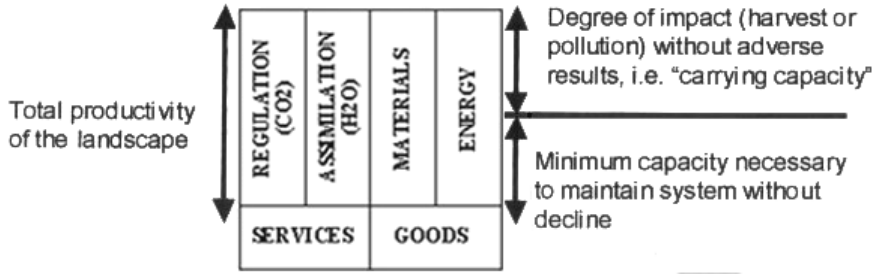

Figure 4: Variation in Ecosystem Capacities, Goods and Services

Clearly not every service and product required is available on every site. Some sites have abundant resources in one area (such as water) and others do not. In cases where sites cannot provide the required ecosystem services, equivalent productive land is borrowed or "banked" elsewhere. This is the typical condition today, the environmental impact of a building is generally much larger than the site it occupies, and therefore the additional required ecosystem services are (consciously or not) taken from off site.

In assessing ecosystem capacity, it is important to note other site characteristics that may limit capacity, such as habitat loss that may not be "harvested" for the given building project, but may be affected. The capacity of a site for regeneration may be determined by factors other than the product required. We must be clever stewards of the environment to correctly recognize capacities and limits in the complex system dynamics of the natural world.

For the purposes of this discussion, the method for calculating both site capacity and environmental impact is given in "Environmental Footprint" by Rees and Wakernagal

3.3 Ecosystem intervention

Most interventions into an intact ecosystem incur a deficit. Harvesting ecosystem resources will generally reduce ecosystem capacity; if the magnitude of the intervention is substantially larger than the site capacity the ecosystem may decline and essentially be lost. Clearly, only the required energy and materials should be withdrawn to reduce the impact. During construction, costs are incurred for extraction of materials; energy is embodied in the refinement and assembly of the building (this is analogous to the biological model of working against entropy). However, the economy of nature is prolific, and it is almost inevitable that over time ecologically productive land will "earn back" the deficit incurred through the initial intervention.

Ecological costs are not only incurred during construction, the ecological operating cost of the project must also be considered. If the amount of ecosystem services required for the operation of the project exceeds the productivity of the project land then deficit will continue to occur and sustainability will be but a wistful vision. If however, operating cost can be brought within the ecological budget of the site then capital will accrue and eventually the project will be not only solvent, but also ecologically profitable. This can be considered a sort of ecological life cycle analysis, projecting when the account will be balanced.

3.4 Designing ecosystem services

Buildings are inevitably considered negative impacts on the environment. This is how they are envisioned, and therefore this is how they are made. We can also consider them in other ways, when we look closely at rocks in the natural environment we often see them acting as frameworks for many types of ecological life; plants, lichen, birds all utilize the rocks for the utility they offer. Minerals leach out, plants latch on, habitats are created and modified by the interactions of sun, wind and water. The rock becomes an essential part of the environment.

A healthy, mature ecosystem has innumerable connections of this sort to engage. Food webs, flows of material and energy, and synergistic relationships are all available for us to connect our buildings. Envisioned from this perspective buildings can be functionally integrated into the local ecosystem, taking up waste and producing resources, providing frameworks for more ecosystems to grow and connect into. The intervention of a building could potentially increase the diversity and complexity of an ecosystem, and increase the productivity of a site through provision of ecosystem services.

At a visionary level we can truly constructively engage our environment. To date we have created and inherited a vast amount of devastated land, polluted rivers, deforested mountains, and paved wetlands. We must conserve and protect the existing ecological resources we have left from additional careless exploitation. Our devastated areas are ideal for ecological restoration and constitute a great resource. We can create ecological "power plants", buildings that also act as factories for the production of ecosystem services in areas that require deep intervention. Frameworks could be created to cleanse water, rebuild soils, sequester CO_2, etc. These could form a distributed network, fitting into ecological niches, evolving with our needs, using the waste of society as raw material, and producing ecosystem resources in return.

3.5 Evaluation

The use of ecosystem services as green building evaluation criteria is straightforward. We require the three previously identified metrics: construction impacts, operational impacts, and site capacity.

Construction and operational impacts are divisible into the material and energy components of each, which in turn, consist of subcategories. Site capacity consists of the initial assessment, any effects (typically deficits) incurred through construction, and the addition of any capacity as provided through the generation of supplementary ecosystem services on site. Once these quantities are established an ecological proforma can be created, which will show the return on investment, ecological deficit created during construction, as well as time required to break even and eventually ecological profit. Many types of economic analysis can be analogously ascertained using this instrument (Figure 5: Evaluating sustainability).

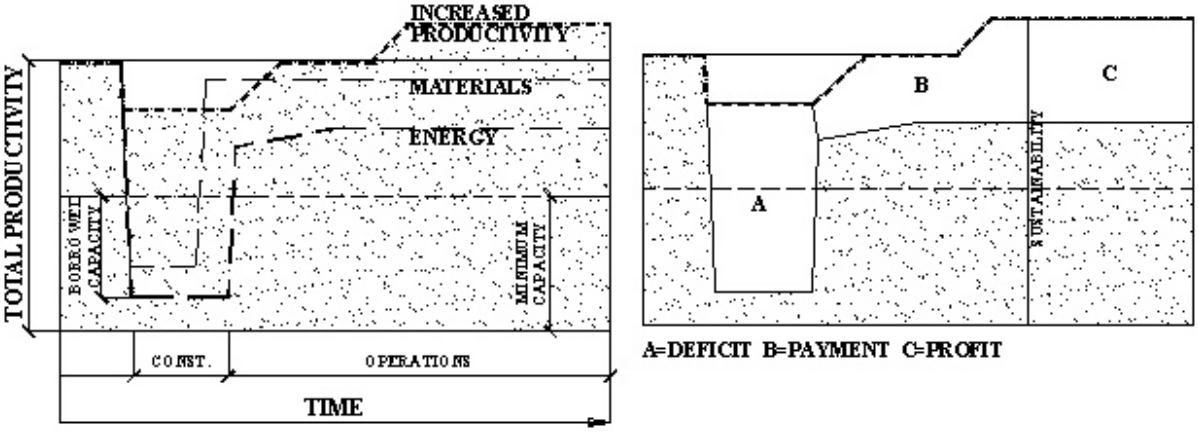

Figure 5: Productivity impacts over time, and ecological deficit and return for energy.

4.0 CONCLUSION

Assessing the environmental impacts of buildings is inherently an interdisciplinary issue. By basing impacts on the capacity of the site we can find a common language between these disciplines and generate useful analysis to assess sustainability parameters. In addition, this has the benefit of generating environmental design criteria that can reduce the environmental impacts of future construction.

In the end however, we must recognize that while we may now be able to assess and therefore generate truly sustainable buildings, this in itself will not make society sustainable. Sustainable design at this moment in time remains a "good neighbor policy", in that the benefits of our actions affect our global neighborhood as much as they do us. This was poetically articulated in Garrett Hardin's seminal thesis "The Tragedy of the Commons", which shows the success of sustainability is rooted in an awareness of the interdependence of our community. It is hoped that the clarity of green building analysis based on the provision of ecosystem services will help generate the collective effort required to build a sustainable world.

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Unlocking the Value in Sustainable Buildings

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1. INTRODUCTION

This paper presents a discussion of the value available in pursuing environmental impact mitigation in design and development strategies for built facilities. This paper is specific to commercial office buildings in Australia, however an effort has been made to draw comparisons with the findings of similar studies from other countries.

Consideration of the "Sustainability" of a built outcome in the broader context of the ecological capacity of the earth is specifically excluded from consideration. It is argued that "sustainable building" is an oxymoron and our consideration and responsibility to outcomes should be seen as a contribution to conservation and environmental impact mitigation.

As practitioners in this field we must create a driver for questioning the business as usual (BAU) approach to building design. We must challenge prevailing industry paradigms that dictate that sustainable buildings are a) simply too expensive and b) achieved by tacking "green" initiatives (such as PV cells or operable windows) onto BAU design. Accepting this as the new or even an interim model provides no better societal, economic or environmental benefit and in some cases it may result in a worse outcome. Shipworth labels those participating in this indolent model "environmental janitors, cleaning up the mess.." (Shipworth, 2002, p140).

Money talks (for better or worse) therefore, by clearly communicating alternatives in terms of design criteria, financial and design outcomes progress can be made. Addressing the risk factors that create barriers is essential and doing so within the context of management strategy and commercial terms can assist in opening doors to the consideration of BAU alternatives. The risk adverse nature of the industry and the barriers it creates is well documented (Hawkins, 2000; Mackley, 2000; Sorrell, 2001; Bordass, 200). As a result, proponents of change are all the more likely to face resistance, particularly where there is any lack of quantitative capacity.

The work cited in this paper consistently demonstrates (across a range of regions) that enhanced triple bottom line (TBL) (economic, environmental and social) outcomes are available to stakeholders throughout a building's life cycle. Moreover, contrary to current opinion these buildings do not need "look" different rather, the key is that their design basis, management delivery and operation is different and they can cost less.

2. GUIDING PRINCIPLES

To lead industry along the pathway to change, our challenge is to communicate to a range of stakeholders in their language, the economic, environmental, design and delivery implications for taking steps to implement a contemporary approach to environmental impact mitigation. The approach required appears globally consistent (Bordass, 2000; CIBSE, 2000; Larsson & Clark, 2000; Mackley 2002; Lovins & Browning, 1992; Romm, 1998 amongst others) and includes ten key principles, including;-

"Ten *Guiding Principles"*

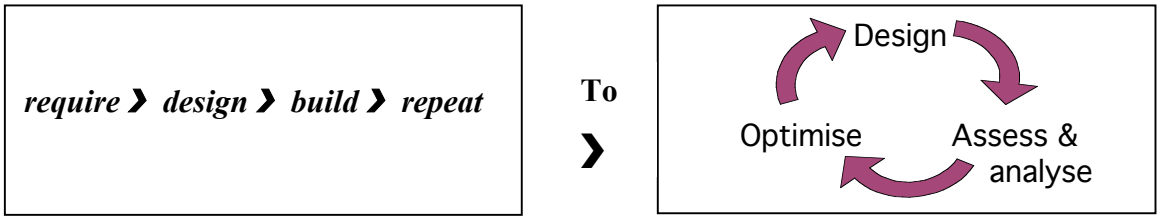
1. ***Understand the project Value-Chain*** **–** Appreciate the opportunities and barriers to unlocking the value in "green" buildings.
2. ***Integrated project management plan*** **–** Ensure the planning and management process allows appropriate design and cost planning times frames and limits.
3. ***Investment in early research and communicate it*** **–** Whilst not essential (as prior experience can be enough) undertaking preliminary research for projects can be of enormous benefit. Establish "value-chain" book-ends and report these in the language of the stakeholders.
4. ***Stakeholder engagement*** **–** Key stakeholders also need to be empowered through the design and delivery process. The earlier in the process this can occur, the better the outcomes. This greatly improves the change of operation matching design.
5. ***Design team appointment with integrated contracts*** **–** It is essential that the project participants appointed "walk the talk" ie: they must sign contracts that bind them to other team members for project delivery.
6. ***Engage in an open life cost plan*** **–** Ensure that the life cost plan is known, understood, agreed and "loved" by all team members. Regular team updates can help guide the whole team.
7. ***Challenge established ideologies*** **–** The project management strategies noted above must provide space for the design team to challenge fundamental design criteria and principles.
8. ***Develop robust performance targets and or design briefs*** **–** Once key principles are agreed and established, the briefs that arise should allow design flexibility, but with performance based deliverable's.
9. ***Implement the best computational tools available*** **–** Outputs from comprehensive and competent modelling are enormously informative and help speed the design process.
10. ***Commit to maintaining monitoring of commissioned buildings*** **–** Anything that can be measured can be managed. Predicting performance means nothing in absence of data from operation. Monitoring post occupancy is essential for future development.

For a more extensive discussion of the ten points above relative to the project delivery process readers are referred to, *Economics of Sustainable Building,* Mackley, 2002.

The principles noted encapsulate a significant departure from the BAU development model. Token application within the development framework will typically result in a BAU outcome. Where all stakeholders are focussed and committed to the range of principles noted, significant success is achieved. Literature is now littered with successful examples of the results that arise from a comprehensive, pragmatic and sensible approach to design (Williams, 2001; Bordass 2000; BCO, 2002; Larsson, 2000; Lovins & Browning 1992; Romm & Browning, 1998; Mackley 2002).

Implementing the ten principles consistently and comprehensively is easier in theory than practice. Literature suggests the awareness and discussion of the environmental and economic impacts of building over design, specification and use of contingency margins is not new but has been with us for some decades (Lovins, 1992; Sorrell 2001; Romm & Browing, 1998). Clearly, a paradigm shift is necessary to cement real changes to the design and delivery outcomes.

Figure 1 – Paradigm Shift Characterisation



An effective means of precipitating a shift of this nature is to communicate successes to stakeholders in the language of risk management that is, ***"quantitative terms***". Moreover, results must be derived from real projects within the context of the design question at hand.

An important issue to consider is that the definition of a "green" building will vary amongst stakeholders. Some may settle for green visual "tack-ons" whilst others may seek design normalcy but operating supremacy. Irrespective of the view, our ultimate goal and responsibility to design and conservation ***must be*** the production of facilities that deliver maximum environmental outcomes for the least marginal life cost, within a range of acceptable market conditions.

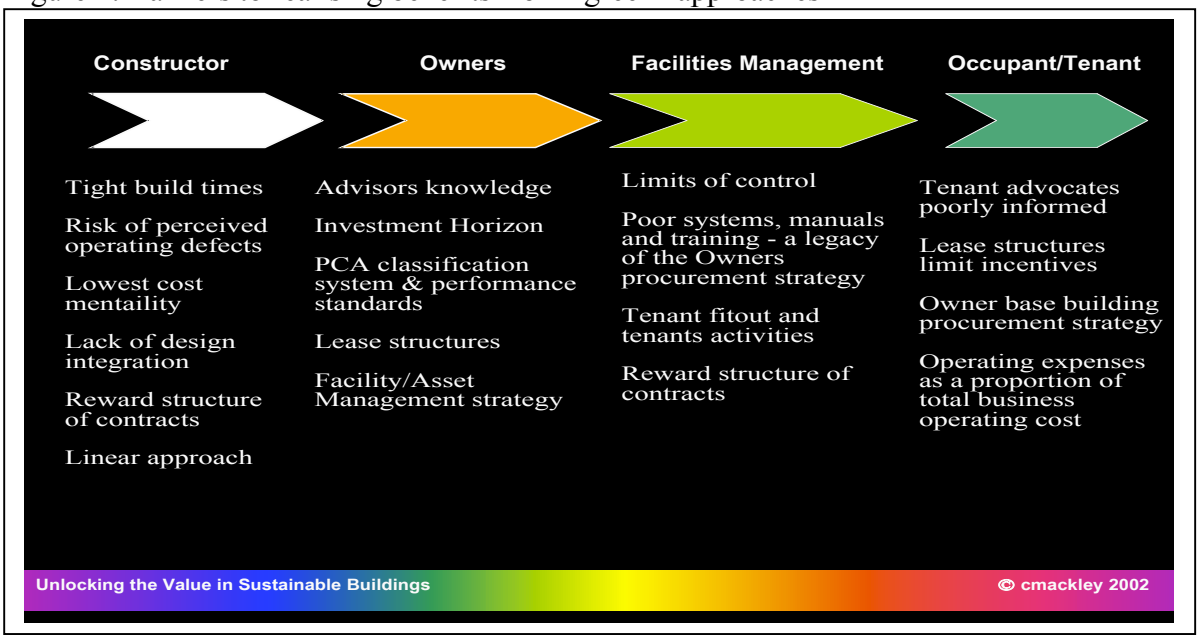
3. THE GREEN VALUE CHAIN

Principle one relates to the appreciation of the development "value-chain" and the barriers and opportunities that it can afford. In this context a "value-chain" is the construct around which key stakeholders derive the benefits that are the reasoning for the development. Most fundamentally, "value" could be perceived as economic. However, the contemporary view increasingly sees value benefits being derived in social terms (ie: workplace health and wellbeing, community connectivity etc.) and environmental (ie: environmental input/output efficiency).

In adopting a holistic and iterative approach, the value chain has the potential to provide significant benefits to all stakeholders. These include;- improved and more stable yields year –on-year yield for property owners; improved profits for constructors; increased management fee opportunities for facility managers as well as improved workplace environments and reduced operating costs for both owners and occupants. It is essential that the whole project team develops an appreciation for the opportunities and barriers to creating value and thereby guides design efforts. Mapping the value chain and its barriers is an essential step to constructing appropriate scenarios and mounting convincing arguments supporting a shift from the BAU model. Without this, the projects cost and time maybe wasted on redundant design and options modelling.

For example, the proposition that "green" buildings afford tenants productivity and churn cost improvements of up to 1% is problematic as the BAU approach renders the value in these improvements for occupants inaccessible to building owners. As a result there is generally no incentive for Owners to make additional investments in work-space "enhancements". A robust method for measurement and valuation of productivity and churn cost improvement, as well as a mechanism for capturing the value within the development decision-making framework is required if these arguments are to be seriously considered. A similar catch-22 exists for a number of other building elements including lighting and façade.

Figure 2. Barriers to realising benefits from "green" approaches



The adverse risk nature of the property industry provides a range of significant barriers to realising enhanced value potential. Figure 2 characterises a range of barriers described in terms of each of the key stakeholders.

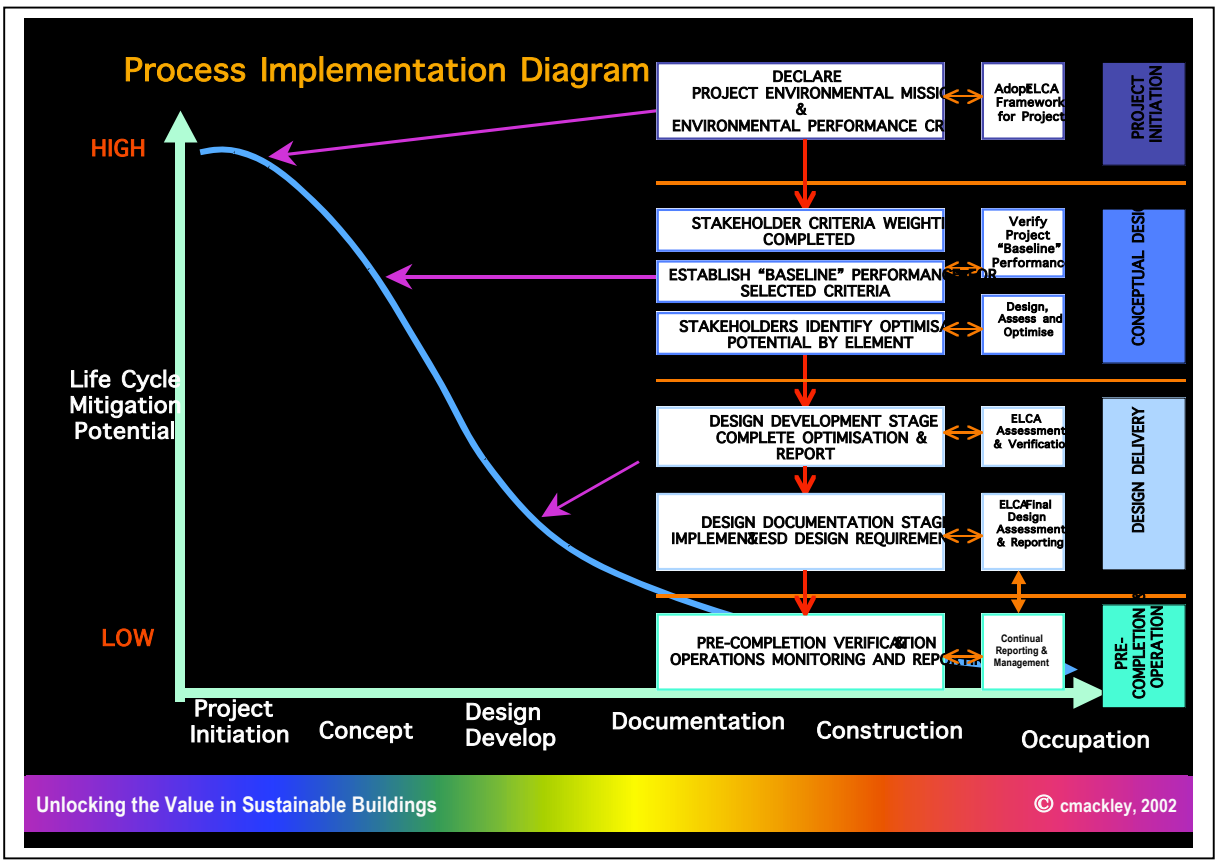
4. INTEGRATED PROJECT PLANNING AND MANAGEMENT

The need for an integrated or holistic approach to project delivery is frequently discussed. What this means is that within the project perspective, the adoption of environmental deliverable's necessitate an appreciation of the resultant impact on both the cost and delivery time-lines. Providing a project cost and delivery process that includes for regular, systematic and quantitative verification of the design relative to the assumptions and variables that underpin the operational performance is essential. In its absence, there is no basis for assessing the value that competing or alternative design solutions provide and certainly no way of measuring success or failure in quantitative terms.

Cost and project delivery plans for buildings with different or high environmental performance ***need to be different***, however not necessarily more expensive overall. A design cost impost of between 0.4-0.7% of gross construction cost appears to be a consistent number internationally that is required in order to support a delivery process that incorporates environmental deliverable's (Larsson, 2000; Mackley, 2002). This number excludes costs or savings associated with the building itself.

A robust delivery methodology designed to ensure actual delivery of desired performance is essential. When developed in consultation with the project team specific constraints and contexts can be incorporated and most importantly team ownership of the outcomes is achieved. Figure 3 below provides an example of a delivery methodology for projects where environmental deliverable's are present.

Figure 3. Environmental process management implementation



5. APPLICATION OF TOOLS TO SUPPORT DECISION MAKING

By its nature, environmental performance assessment necessitates the application of a range of tools to support decision making in multiple dimensions. Decision making and weighting frameworks are often based on a combination of cost benefit, life cycle and multi-criteria decision making theory to provide a marginal cost weighted in societal or stakeholder terms. These tools are essential for a number of reasons including; design guidance to teams in relation to stakeholder priority; assist broad decision-making; identify the life cycle impacts and support quantitative success declarations amongst other things.

In addition, dynamic building science modelling linked to environmental deliverable's provide a level of information that enables designs to be substantially engineered at or prior to conceptual design stage. This usually means that the delivery cost of the design can be optimised prior to market exposure. Appropriate management of this phase generally sees additional design fees returned to the bottom line of the building cost multiple times (Mackley, 2002; Larsson, 2000; Romm & Browning 1998; Lovins & Browing 1992). Good management of these tools is essential to ensure that the design solutions that deliver real benefits are favoured.

"Green" buildings can cost more where a normal building is highly featured. Anecdotal evidence available to the author (commercial confidence prevails) suggests "featured" buildings to cost between 5-10% gross construction cost more per square meter to build. Bordass notes "..a sound, robust, no frills platform with a clear adaptability strategy may offer better value than a more highly featured solution procured on the cheap" (Bordass, 2000, p341). There is extensive international data (that supports the authors own findings) to show that it is possible to reduce the capital cost of commercial buildings conservatively in the order of 1-2%, improve floor space efficiency by similar orders and reduce operating costs in excess of 15%. To achieve this a rational, sound and robust approach to design must be adopted that is based on the premise of questioning fundamental design criteria ideology and adapting it (Bordass, 2000; CISBE 1998 & 2002; Lovins & Browning, 1992; Hawkin, 2000; Romm, 1998; Mackley, 2001 (b) & 2002; Williams, 2001).

6. CONCLUSION

It is hoped that this brief paper has presented evidence to support the assertion that significant and multiple benefits are available to all building stakeholders by adopting an alternative approach to design and development. These conclusions appear to hold for Australia, UK and North America. This is encouraging. In addition is it argued that;-

1. Conservation and environmental impact mitigation doesn't need to ***"cost"*** Rather, infinite positive value (economic, environmental and social) is accessible to all stakeholders in either a new build or existing solution.
2. Accessing value is absolutely determined on questioning, challenging and modifying prevailing design fundamentals and risk structures.
3. An acceptance that in relation to building "sustainable development is ..a pathway for change and not a goal or end state" in itself (Shipworth, 2002, p140).

What constitutes a "greener" outcome will vary with context and stakeholders. Some of the keys to progress include incorporating sustainable principles into management planning as well as attention to continuous research and development.

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Preschools buildings in a hot humid climate

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1. ABSTRACT

In this paper the proposal of a preescolar is shown, carried out by students of the third year of the TALA Unit of Facultad de Arquitectura y Diseño de la Universidad del Zulia, Maracaibo, Venezuela. The proposal has been conceived integrating the bioclimatic strategies with the architectural materialization of the process of growth and the boy's learning.

The position leaves of a previous proposal presented by a student of the previous year, and starting from the same one the whole position is developed, conserving the principles conceptual generators, taking them to the architectural detail in coalition with the bioclimatic strategies necessary in the hot humid climate to reestablish the thermal comfort conditions; to achieve trough, crossed ventilation, external thermal isolation, interior thermal mass, eolic chimney, solar protection, bioclimatic landscapes, appropriate materials were used.

The proposed has been evaluated in the heliodón, the wind tunnel and the thermal simulation program CODYBA, with the purpose of demonstrating that through the architecture conjunction and the climate if it is possible to generate spaces that elevate the quality of the common citizen's life in regions of the Third World.

2. INTRODUCTION

The third year of architectural studies of educational unit T.A.L.A. (Latin American Architecture Workshop) made an exercise based on the evaluation and development of conceptual positions of a group of students from the second year of the same unit previously proposed.

The site for the project is located in the San Francisco Municipality, “El Manzanillo” Neighborhood on 10th street (Union). The immediate location is made up of a main avenue, the “Fe y Alegria” school, mostly one story buildings and small business (fast food shops and repair shops). All these immersed in a great brown mass, made up mostly of the houses, connected by sandy roads. This is a typical configuration of a **c**ongested suburban environment of the third world, in this context with no planification or any aesthetics values, denied by a self-absorbed concrete mass, although they share the same function. The site is treated more like a space without local identity than as a point of character and potential worthy of being exploited.

In Maracaibo, pre-schools are established mostly in family houses which change their function from residential to educational. These housings are conformed by a rectilinear functional scheme

of continuous spaces joined by corridors. Many of these places lack natural light and ventilation. The green areas are almost always considered the negative spaces of the land.





Figures 1. Pre-school facilities in Maracaibo

There are also public facilities that, in most of the cases, follow a pattern of standard school. This pattern is formed by bar buildings that form identical serial spaces built with concrete block walls and metallic light covers without considering the well-being of the users, since most of the ventilation is in the mid area and not the lower area where most of the children are. The location, dimension, and height of the openings are specified by a specific canon, without taking into consideration the specific geographic location necessary for each preschool.

Neither this disposition of construction materials, nor the interior quality of the facilities (public or private) respond to most of the requirements demanded by the Education state department Ministry.

3. THE CLIMATE OF MARACAIBO

Maracaibo, is the second most important city of Venezuela, it's located at 10º 40' north latitude and 71º 30'longitud west, it is a city characterized by a humid very warm climate the whole year. During the month of August, the maximum temperature reaches 32, 85 ºC and the minimum temperature in January averages 23,12 ºC. The relative humidity oscillates during the whole year between 50% and 95%. The yearly precipitation averages 490 mm. and a maximum in 24 hours of 105mm (The Roche et Alt., 1997). The predominant winds are from the NNE and the breezes are loaded with humidity due to the presence of the Maracaibo Lake and the Gulf of Venezuela. The average wind speed is 3 m/s, presenting periods of calm. The solar maximum radiation over the horizontal plane approaches the 600 w/m2 and the maxima overcome the 900 w/m2. The diffused radiation values are near to 65% of the total radiation received (The Roche et Alt., 1997).

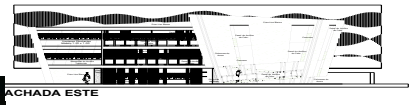
4. CONCEPT AND BIOCLIMATIC STRATEGIES

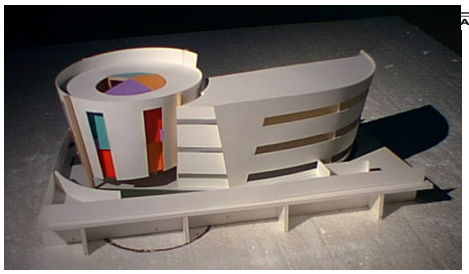
4.1 Compact bioclimatic entity as scenario for preschool learning

The objective of the proposal is to be able to represent the children's growth in analogical terms through the forms of the building; from this, three marked areas arise: The *"inverted eolic cone"* (IEC) is the circulation volume that represents the child's growth, it is similar to what the evolution and the development of a child can be, mainly for their learning. This element is presented as the only way for vertical circulation. The elements that sustain the meaning of the volume are: a) The *upward spiral* constitutes the vertical circulation of the pre-school and directs the users toward the *directional bands*; b) The *focal emptiness*, located in the center of the IEC,

defined by the upward spiral, is where the essence of the proposal is perceived, since the progression of the growth through the ascent of the spiral is felt; c) *divergent forces*, their purpose is to reaffirm their challenge to gravity.

The *"directional bands"*; where the classrooms are distributed, and where the process of growth is developed, leading like guides to the IEC. This idea was represented without the use of marked closings that would confine the classrooms to a unique physical space. In the teaching process an independent plane is presented as a directional line of growth which separates it with the exterior, where a non-gravitational *speedy plane* takes place in order to become the main permanent closing of the spaces.



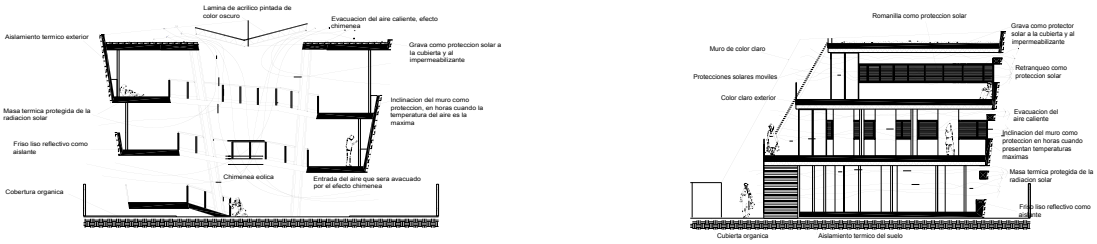


Figures 2. The project. Heliodon Evaluation

The *linking volume*, serves as an articulation, integrating the EIC with the directional bands, merging these areas. All the service facilities required in the proposal such as: bathrooms, depositories, water filters, bookcases and lockers are located here.

4.1.1 Bioclimatic strategies: Inverted eolic cone (IEC) the ventilation works in an upward fashion; for this reason the center of the volume has a lifted cover that allows the evacuation of the air from the internal hole. This inverted eolic cone is conformed by:

- *Screening leaves* which are acrylic panels located in the interior of the IEC that tame light.
- *Vertical holes*, interstitial spaces formed by the conjugation of the solar light beams and the internal panels that allow the entrance of natural light and the exit of the hot air in the different levels of the IEC.
- *Merging panels* are responsible for unifying and defining the *directional band* and the *external band*, they can be manipulated according to the activity, allowing the entrance of natural light and air.



Figures 3. Bioclimatics Strategies

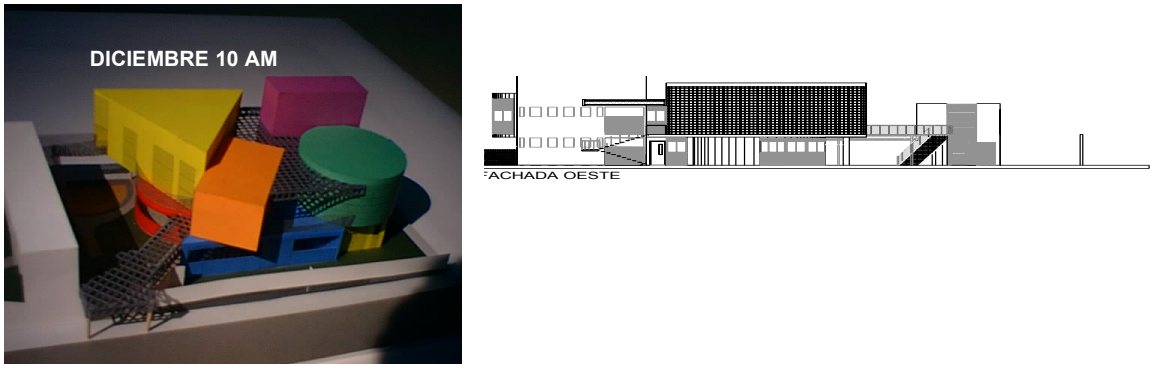
- *Non-gravitational speedy plane* (NGSP), this plane oriented towards the west protects the *directional band* (where the learning process takes place) from solar radiation at noon hours, reinforcing the function of the recessed openings facing west.
- *Dark horizontal fissures* emphasize the speed of the (NGSP), allow the exit of the internal air flow, and the recessed fissures provide solar protection during most of the afternoon hours. And the louvers system protects from solar radiation allowing air flow at the same time.

4.2 Random toys as a Place

This space offers freedom and motivates imagination. The primitive volumes seek immediate identification of children with their school, before a non competitive location at urban level.

The composition is clear: the central body is conformed by a group of posed pure volumes in a random way on the land, concentrating on its interior the axis of vertical circulation and the less flexible spaces, witch are the services.

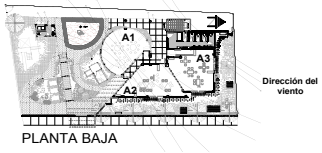
If some term can define the character of this project, is experimental. Their interesting spatial sequence comes largely determined by specific programmatic characteristics, outlined originally so that children with physical inability and learning disabilities can be integrated to the activities of a regular school. To take the experimentation to it's limits, has enabled the creation of textures and systems that, even though carried out with conventional materials, they are capable of recreating incredible situations.



Figures 4. Random Toys as Place

4.2.1 Bioclimatic Strategies. Tri-phased wrapping with visual/eolic/solar properties. The facades have been treated as a wrapping with a filter-like characteristic totally penetrated in three bands: 1. band of heating dispersion, 2. ventilation band (thermal well-being) and visual, and 3. ventilation Band (thermal well-being) and punctual visual, it covers the volumes vertically and by this way it minimize their resistance to the wind and at the same time, it diminishes the transmission of heat. The design of this bands responds to reaffirm the form of the volumes in each one of its sides, generating a diversity of facades with unique compositions.

- " *The language of the non-gravitational*", container and silent plane, ¨levitates¨ from the floor leaving a transparent and permeable space allowing the wind through and by these means



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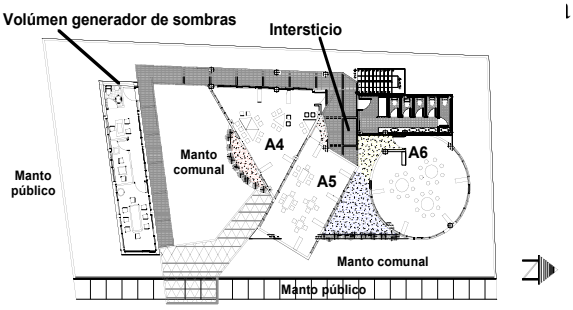
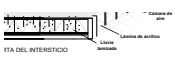


PLANTA ALTA

Figures 5. Plan views of the proposal

- " *The communal ground*"(I space park), is totally covered with a thick layer of vegetation with the purpose of reducing the albedo of the environment. This place was specially design for hosting outdoor activities and games satisfying its main function, witch is to fulfills the specific requirements of a early childhood play ground.
- *"An active filtrating bar"* extends around the south and west facades with the purpose of blocking the solar radiation and to channel the winds toward the classrooms and to the communal ground. This active filtrating bar, made up of a chain of leafy trees allows to cool the space by the evaporative transpiration process.
- " *The generating shade volume"*. This place, designated for the administrative function, is suspended from the floor. It consists of openings in the four facades with the purpose of generating total shade on the communal ground in hours of the morning and then offering the same shade quality on the public ground (the public park space) in hours of the afternoon, generating shade at all moment in the ramp, avoiding the need of a system for solar protection.
- " *Morphological inequality"*. The irregularity of form and height of the volumes, generates a diversity of shades that diminishes the transmission of heat of the surfaces and at the same time, provides shade to the external space, also benefiting the canalization of the breezes.
- *" Inhabiting emptiness*. Knowing interstice as the space between two objects, this project takes it as a connecting space among the volumes that represent the toys always keeping their characteristic of open space, and at the same time contained by themselves. In this space the Venturi effect takes place. The interstice will have the job of allowing the circulation among the volumes and at the same time playing a neglecting role among the group of the toys, that is to say, this will enter among the volumes with a completely different presence in function, as in materials, as in the special quality that it generates, and moving along the site with the purpose of connecting the group of volumes that constitute the classrooms, with the administration volume,



making it basically through the ramp and gangplank. Here we can notice then, the element that ties in some way and links our project as whole.



Figures 6. Bioclimatic Strategies

- *" Interactive Wall*. This shade generating wall and idea stimulator, offer the opportunity to all the preschool users to intervene in this façade.. This façade is located in the west of the preschool, where the ramp reaches the volumes, creating a transitional space from the direct light, to a filter of sifted light, until arriving to the space of interstice. This wall filters the light through cylinders of colors that tint the sun and define the shades in extensive range of gray, besides acting as a guide of the wind toward the interior space of the classrooms, refreshing the inferior area where the children are most of the time.

5. THERMAL SIMULATIONS

The buildings were analyzed taking as reference the data of the Meteorological Station of the Institute of Investigations of the Faculty of Architecture of The University of Zulia. These values were ratified in the psychometric chart, with the thermal comfort area proposed by Givoni in 1969 to determine the recommended design strategies.

The interior air temperature values, relative humidity, and resulting interior temperatures were obtained using the computerized simulation software for the analysis of the thermal behavior of buildings in dynamic régime "CODYBA" (Brau et al, 1989), developed in the INSA, Lyon, France. To achieve these results, this analysis requires a period of 3 days.

The bioclimatic evaluation of the proposals were carried out during March, the vernal equinox; and June, the summer solstice. The simulations were carried out taking into considerations of maximum interior temperature, medium internal air temperature, and the coefficient of thermal stability.

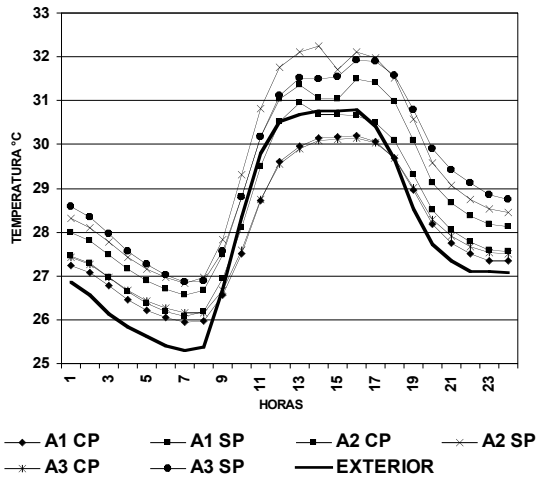
5.1 Thermal analysis of the Compact bioclimatic entity

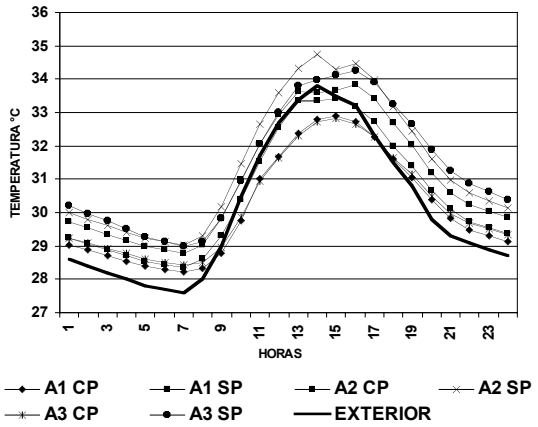
In the lower level classroom (A1-WP) the simulations carried out during June, showed that the maximum interior temperature is 0,94°C lower than in similar classrooms (A1-WOP) without solar protection and without any type of bioclimatic strategy. This is due to the use of solar protection, isolation thermal interior and internal thermal mass, the latter diminishes the external maximum temperature impact. For the classroom located on the first floor (A2 WP), the simulations carried out during June, show that the maximum interior temperature is 1,32°C lower than in the one not using any thermal approach. The classroom of the top floor (A3 WP) during

March, shows that the maximum interior temperature is 1,42°C lower than the same one without any thermal approach. The difference in this last simulation is more evident because of the lack of external thermal isolation on the roof of the classroom without any bioclimatic approach.

The average temperature in the open building during the 24 hour-period with solar protection is the same as the average of the exterior of the building. The most unfavorable maximum temperature during March is 0,93°C more than the maximum temperature of the exterior in the models of the building without solar protection, showing the difference of the more favorable alternative when the exterior temperature is 1.06°C.. The results of the simulations on March are shown in the figure 11.

The coefficients of thermal stability (Neila and Bedoya 1997) oscillate between 0,80 and 0,92. These values were obtained dividing the variation of the interior temperatures of the models which oscillate between 4,40°C and 5,06°C, because of the variation of the external temperature which is 6,2°C.





Figures 7 and 8: Behavior thermal interior in the classrooms during March and June

5.2 Thermal Analysis of the random toys as Place

The average temperature in the open building the 24 hrs., with solar protection, is the same as the average of the exterior of the building. The most unfavorable maximum temperature during March is higher 0,98°C than the maximum temperature of the exterior, in the models of the building without solar protection, and the difference the most favorable alternative and the exterior is of 0,79°C. The results of the simulations in March are shown in the figures 9 and 10.

The coefficients of thermal stability (Neila and Bedoya 1997) oscillate between 0,87 and 0,99; these values were obtained dividing the variation of the interior temperatures of the models that oscillate between 4,78°C and 5,46°C, for the variation of the external temperature that is 6,2°C. The average temperature in the open building during 24 hrs., with solar protection, is the same as the average of the exterior of the building. The most unfavorable maximum temperature during March is higher 0,98°C than the maximum temperature of the exterior, in the models of the building without solar protection, and the difference of the most favorable alternative of the exterior is 0,79°C. The results of the simulations in March are shown in the figures 9 and 10.

The coefficients of thermal stability (Neila and Bedoya 1997) oscillate between 0,87 and 0,99; these values were obtained dividing the variation of the interior temperatures of the models that oscillate between 4,78°C and 5,46°C, for the variation of the external temperature is 6,2°C.

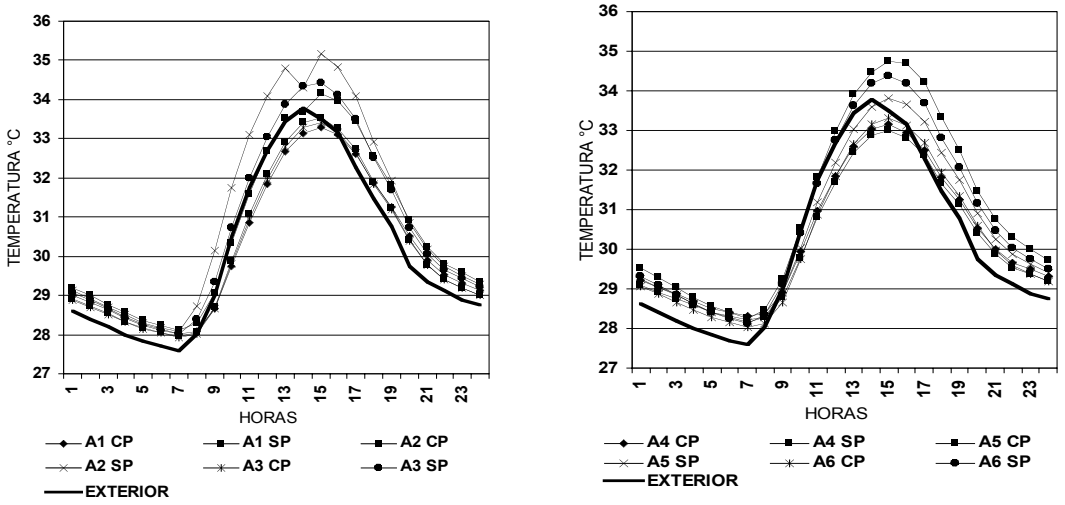


Figure 9 and 10. Thermal interior behavior in the classrooms during the month of June

6. CONCLUSIONS

The theoretical conclusion proves that a project developed for a warm-humid climate, taking into consideration all the bioclimatic factors, with the use of appropriate strategic methods, elements and materials, can be made possible..

It is demonstrated that it is possible that the educational institutions of our city can respond in an appropriate way with the use of materials and appropriate technologies in accordance to the demands of the communities, increasing the of quality of comfort. The bioclimatic evaluation carried out in the proposal demonstrates that with the proper use of the traditional constructive systems and solar protection in the openings, the maximum temperature of the interior air is below the external maxim.

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Biopositive constructions as elements of sustainable building

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Biopositivity of buildings and engineering structures is their ability to be an organic part of the natural environment (of ecosystem). Biopositive buildings cannot destroy and cannot pollute natural environment. They must restore the nature, must be adapted (bio-adaptive) for existence of animate nature on external surfaces of buildings and inwardly volumes of engineering structures. They must save resources and must not require for the fabrication of buildings of nonrenewable resources, must create not barriers on way of natural flows of materials and energy, not produce pollution that cannot be processed by natural environment, create high quality life and save medium of life. Thereby, biopositivity of buildings and engineering structures is integral notion, composed of main requirements to nature saving and nature restoring objects. Biopositive buildings and engineering structures in every city can allow in certain degree "to return" to nature some part of territory with soil - vegetable layer and to create new additional planted greenery (grass, trees and shrubs) areas that can help to stop a retreat of nature under anthropogenic pressure.

Biopositive reinforced-concrete constructions are buildings and engineering structures, which are perceived organically by an environment as cognate to it objects, they allow existing on the surfaces to green plants and small animal (birds). They are well perceived visually. The author has developed wide complex of biopositive constructions for conditions of complicated relief of Black Sea coast (Crimea) assisting to restoration and conservation of nature. New constructive decisions of spatial buildings and engineering structures were offered, designed and explored. All these buildings and engineering structures are polyfunctional and ecological biopositive designs and they are executed in the form of efficient and beauty spatial structures. There were produced in form of reinforced concrete cylindrical shells, folded plate constructions, and other shells. The reinforced concrete shells are ecological solutions, as they have small expense of materials, well work in soil filled constructions, and are visually beautiful. Multifunctionality and ecological compatibility (biopositivity) of buildings and engineering structures is concluded in their abilities simultaneously to execute main functions (homes, retaining walls, noise protected walls, keeping of landslides, coast-protecting structures, etc.), as well as allow a planting of greenery on vertical and horizontal surfaces, to grant asylum (ecological niche) for small animals. One of the first conditions of building biopositivity is a making a possibility of existence and growing of plants on their surfaces. The plants must by fastened on vertical, horizontal and sloping surfaces, they improve condition of air and water, clean an air and water from contamination, improve micro-climate, create a biomass, ensure existence of microorganisms, create a sound- and warmth- protection, improve an exterior of engineering structures, its visual perception.

It is possible to build such buildings on uncomfortable for usual building up territory - on slopes, in hollows, in ravines. The spatial seashore protective structures are filled by substratum (large stones), on which grow undersea plants and living organisms, cleaning seawater in the coast area. Some experimental polyfunctional biopositive designs were

investigated (retaining and noise protective walls - shells, buildings on slopes, buildings that restrains landslides, buildings – retaining walls, seashore protective structures). These investigations have allowed determining real stressed - deformed state of these designs and ways of their calculation. The experienced constructions were executed in Crimea (ashore Black Sea). Experienced constructions have shown high efficiency as new ecological polyfunctional buildings and engineering structures.

Biopositive retaining walls shown in fig. 1 were projected and are made according to enunciated above positions. The walls, which right side after assembling looks like honeycombs, consist of two modular parts – folded plate and beam. The elements was placed each over other on cement mortar, simultaneously fulfilling backfilling and filling of interior volume of honeycombs by vegetative soil. Such wall works after erection as massive retaining wall, but it has smaller volume of concrete. Ground filled retaining wall has beautiful appearance and much more economically than other types of walls.

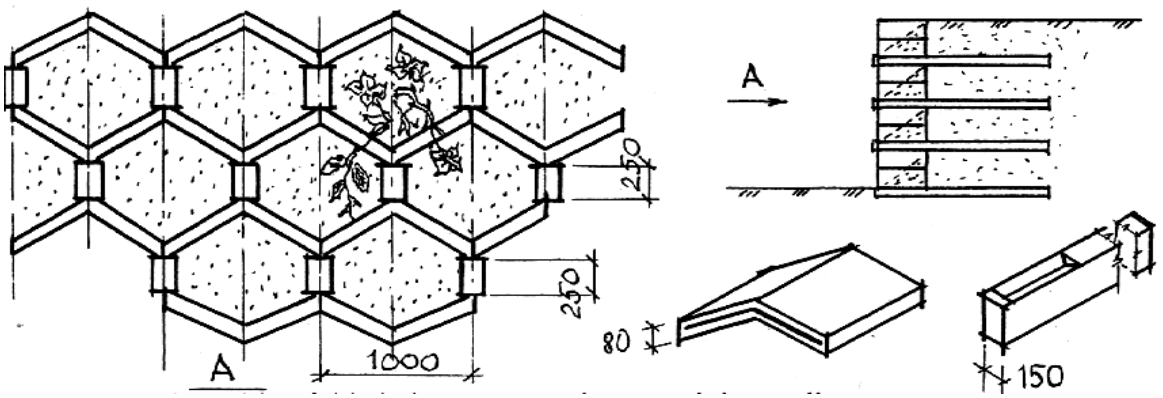

Fig. 1. One of types of biopositive retaining walls

Like biopositive noise-protected walls are multifunctional constructions, in which are strengthened noise-protected functions by planting of greenery of front face and top of wall, and also the appearance of walls is improved. Ecological compatibility of constructions is their ability to absorb pollution and thus to clean air. All designed types of noise-protected walls are ground filled walls, in which the soil-vegetable stratum fills volumes created by reinforced concrete walls, and this soil in bottom contacts immediately to natural soil. It allows landing a grass, creepers and small bushes without necessity of constant special watering, as roots of plants can allocate in natural soil (it is recommended to select plants with lengthy roots penetrating into natural soil).

Constructions of biopositive seashore protected structures should maintain environment of habitat of coastal organisms and plants or to frame an artificial environment. It was achieved by making of stone filled of internal volume which freely washed by water and accessible to sea organisms. Massive biopositive seashore protected structures was fulfilled as volumetric reinforced concrete element (box). Embrasures were made in walls of box for rising of biological activity and are filled by stones. Thus inside of biopositive seashore protected structures was created convenient medium for development, reproduction both protection against enemies and waves of major number of ground both coastal animal and plants. These organisms clean ocean water from pollution. Besides this construction improves water circulation in seashore space, enlarges the content in it of oxygen and nutritious substances.

According to mentioned above demands to biopositive buildings, were constructed separate multifunctional biopositive buildings on territories inconvenient for traditional building. It is possible to mark pavilion for sleep at coast of Black Sea representing building - retaining wall for slope about 7м; This building is also landslide protected construction, and providing perception of seismic loads (fig. 2). The building is constructed for steep slope and supports by back wall vertical slope of soil; besides one of parties of building has landslip, which also is retained by multifunctional building. In connection with activity of big distributed loads - active pressure of soil - the pavilion is fulfilled as building from arches, which base on hard communication towers fixed in crosses of arches. The special interest represents that the building is completely inscribed in relief, and it is completely imperceptible at the enough major sizes (length - about 150 m, breadth - 11 м. It was not required carryings out almost of excavation and rearrangement of historically usual relief. At traditional mastering of steep relief it would be required to construct high retaining wall and near it to create building (such solutions are widely applied in Crimea).

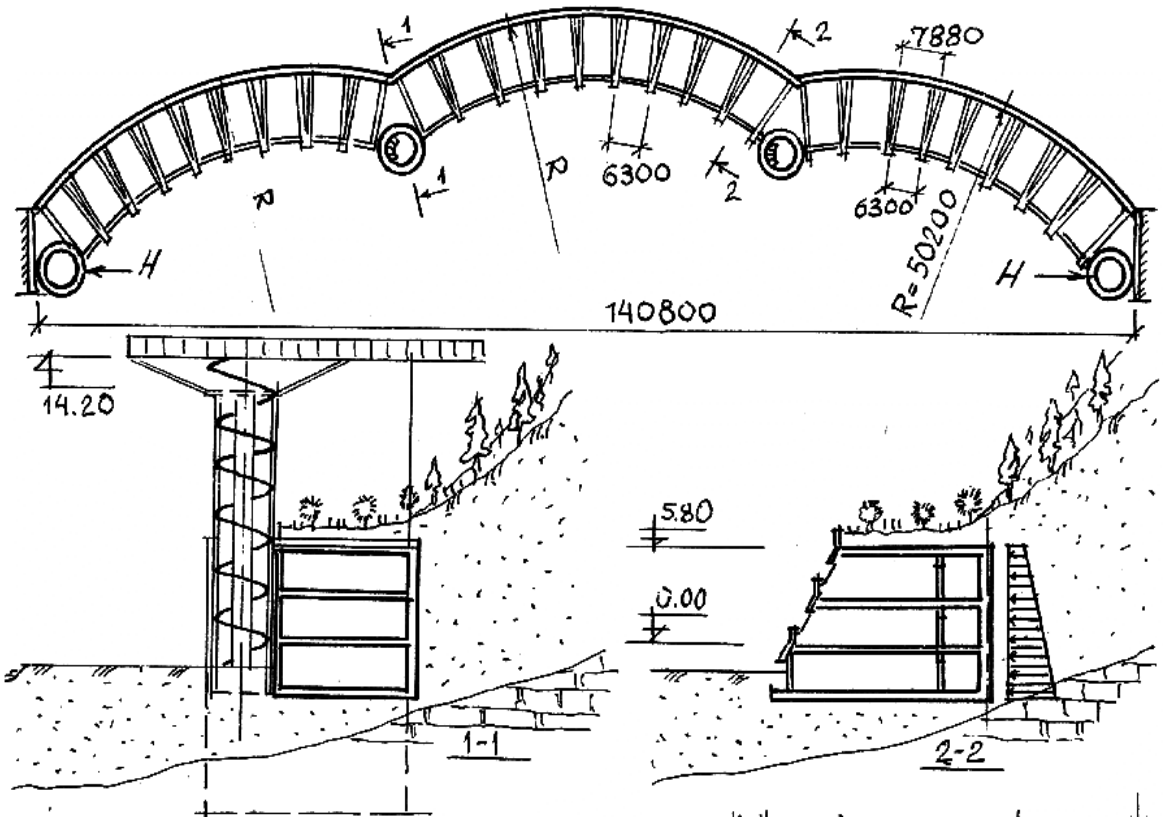

Fig. 2. Multifunctional building

The school complex is constructed in Yalta on steep slope partially dip in soil of slope and resting by special inclined construction in firm ground. The school stadium is fulfilled on banked roof of part of building, dip in soil. There is ended construction of unique under design solution building of sanatorium on steep slope 32^0 (fig. 3). The base of building is original: for exception of terraced development of slope (traditional at construction of buildings by usual methods and causing, except for major and laborious excavation, possible activation of landslips and rearrangement of relief) on plainly planned slope stack reinforced concrete lattice resting in bottom of slope in pile cap. The reinforced concrete disks of overlaps are attached to this lattice, and lean on columns fixed in places of cross of inclined and horizontal strips. Thus, the plates of overlaps have very high hardness in horizontal

direction (they are hard horizontal diaphragms attached to bases and changing usual vertical diaphragms). The seismic efforts are perceived not by vertical diaphragms, as in usual reinforced concrete buildings, but by horizontal diaphragms, attached also to the bases. It practically eliminates activity of horizontal loads on vertical columns, that allows to fulfill by their thin enough, and clusters - not hard. This design solution has provided reliable perception of seismic loads, stabilization of a possible landslip (the building presses landslip to slipping surface instead of its motion under weight of building at the traditional solution).

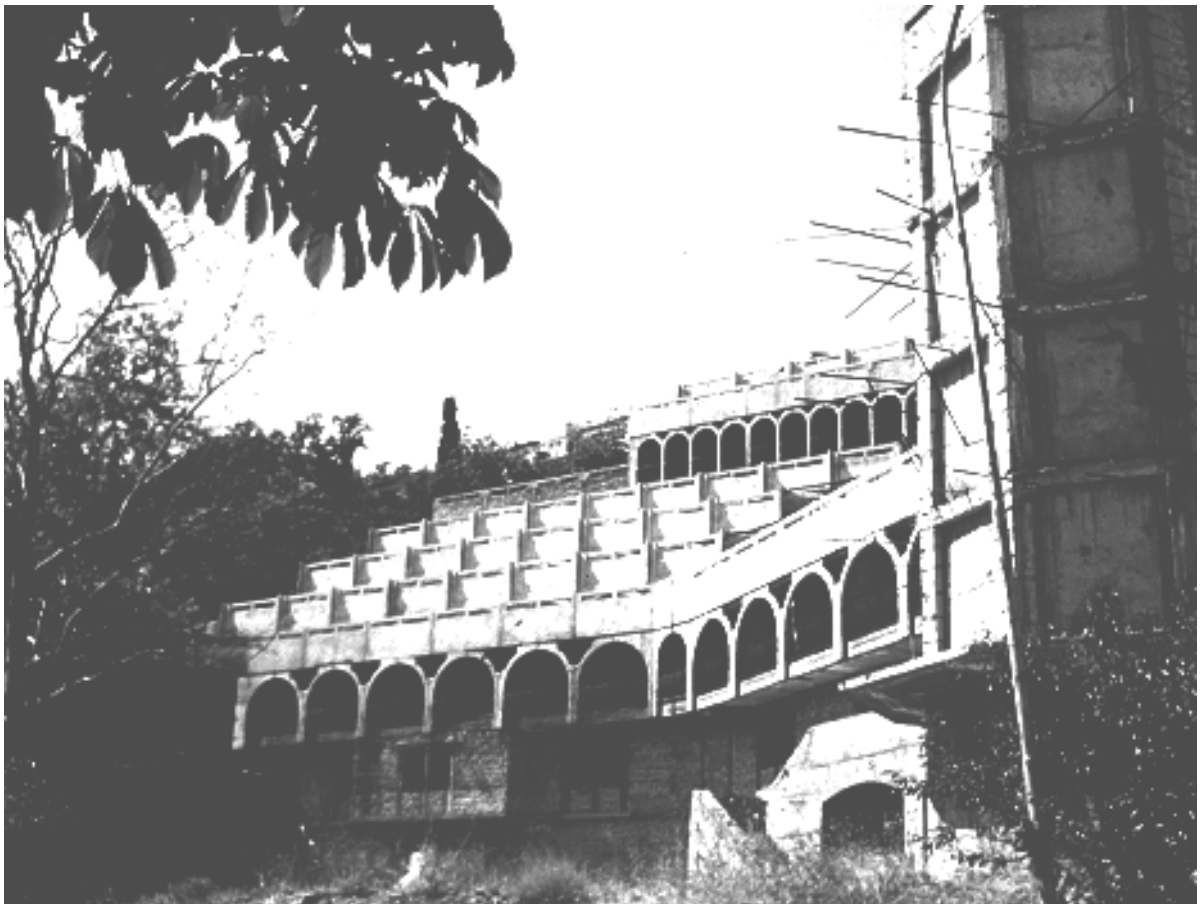

Fig. 3. Sanatorium on steep slope

The functions of biopositive building or engineering structure can be strengthened by usage of renewable energy. The actively biopositive building or engineering structure should be multifunctional and alongside with basic function (apartment house, industrial building, seashore protected structure, etc.) should fulfill of one or several nature protection functions, connected with fastness of relief or with clearing of free air and water from pollution and with other possible nature protection functions. Series of attractive padding properties of city can frame permaculture (permanent agriculture - stationary value agriculture). Permaculture is rather new trend in agriculture of city and in architecture. It began to develop as multipurpose approach to each site of territory for making of highly productive ecological system for production of nutrition and for improvement of quality of city medium. Permaculture in city can help to aggregate building, landscape, long-term and one-years plants disposed on all possible surfaces, in stable system. One of original positions of permaculture for cities is usage of all surfaces of buildings and structures for fastening or growth various plants, which crop in ecologically clean city can be utilized in nutrition.

However, it is not limited bio-adaptability of biopositive building for making the life conditions for different plants and animals. Person must afford animals and plants the ecological shelters (areas), which were occupied by artificial objects. It is necessary to analyze questions of ways of urban ecological help to animate nature. There is order of giving of biopositive characteristics to buildings and engineering structures.

There are sufficiently much ways of designing of buildings and engineering structures with biopositive characteristics - from biopositive material to collection of rainwater and salvaging of departures. Buildings and engineering structures can be subject to the following analysis:

1. All possible vertical and horizontal surfaces are used for planted of greenery?
2. All possible vertical and horizontal surfaces are used for creation of soil stratum on surfaces?
3. Whether the demands are satisfied to permaculture and phytomelioration?
4. Whether the demands are satisfied to miniaturization of object, to its correspondence to sizes of natural forms?
5. Whether the demands are satisfied to visual ecology?
6. In full measure are used ecological building materials?
7. Whether the demands are satisfied to polyfunctionality of buildings and engineering structures?
8. Is a possibility to use waste for fabrication of separate ecological building elements?
9. Whether the demands are satisfied to maximum dismissal of soil-vegetable stratum from building?
10. Whether the demands are satisfied to permeability of hard covering of soil?
11. In full measure is used underground space for buildings, engineering structures?
12. Is a possibility to make shelters for small birds and animals?
13. What ways of energy saving and utilization of internal heat are used and that else possible to do?
14. What renewable energy possible to use in the region of construction?
15. What devices for utilization and accumulation of renewable energy possible to unite with designs of building, engineering structures?
16. All possible ways of architectural-building bionics are used in the project?
17. Whether the principles of similarity to nature are accepted in attention?
18. Whether the demands are satisfied to "clever" and intellectual characteristics to the building, engineering structures or its parts?
19. Whether all is made for the most full achievement of object autonomy (independence or small dependency from external networks of water supply, sewerage, heating, energy supply, and gas)?
20. Is the architectural environment of city (or of block, separate building) beautiful environment for inhabitants?

Almost ideal ecologically beautiful biopositive building (fig. 4) can be created as result of more complete solution of problems of biopositivity. New concept of ecological beauty of buildings and city has arisen as a consequence of development of ecologization process of buildings, engineering structures, and urban technologies. The rather new science - architecturally - building ecology - offers the whole spectrum of the ecological decisions of concerning separate buildings and city as a whole. Among directions of the account of ecology of the man, influencing to sustainable development, there is maintenance of intercourse of the inhabitants of cities by means of architecture, including intercourse of the neighbors in houses, inside quarters, in cozy and planting of greenery courtyards. A major task of architectural ecology is the constant ecological education and formation of the

inhabitants of cities by beautiful and healthy architectural and landscape environment for the inhabitants. For constant education of all inhabitants by means of architecturally - landscape ecology it is necessary not only creation of beautiful and healthy, clean and pleasant for sense organs (sight, hearing, sense of smell, and even of touch) environment, but also participation of all inhabitants in maintenance of its quality. Only personal participation in maintenance of ecological and beautiful environment can result in personal interest of the inhabitants in these actions and to return process of positive influence of environment of city on education of the inhabitants. For this purpose the architecture of cities, buildings and engineering structures should be ecologically (bio-positively).

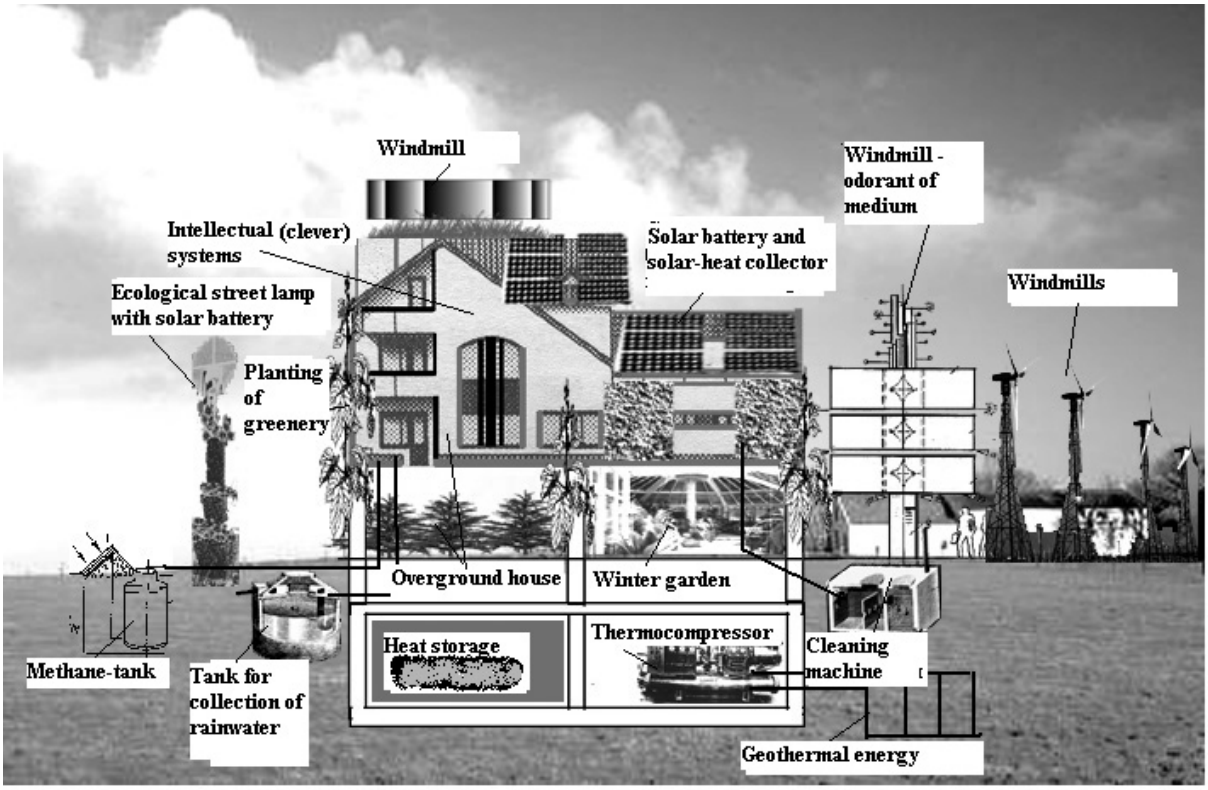

Fig. 4. Almost ideal biopositive house with great number of biopositive functions.

CONCLUSION

Biopositive buildings and engineering structures are not only nature preserving constructions, but they have very good visual attraction. They can allow "to return" to nature some part of polluted territories, create additional soil - vegetable layer and new planted greenery (grass, trees and shrubs) areas that can help to stop retreat of nature under anthropogenic pressure.

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Program of Sustainable Designing and Building of Moscow

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Sustainable designing and construction are designing and construction, which assist making and healthy life of sustainable city, sustainable locale, sustainable society, or support of sustainable development. It is substantially connected with ecologization of city, with its ecological reconstruction, with ecologization of human activity in city and with ecologization of buildings and engineering structures, with ecologization of wide circle of human needs. Ecologization of city, buildings and engineering structures is connected in turn with ecological restoration of all components of landscapes, with creation of ecological equilibrium between city and natural medium. At the same time sustainable designing and construction should promote and other conditions of sustainable development, - for example, encouragement of contacts of city dwellers, support of their joint activity on making of beautiful city, on organization of ecological formation and education during life of population, on support of sustainable development of city.

Sustainable designing and construction should be to support of sustainable development of city. The offered "Program of sustainable designing and construction of Moscow" includes the basic directions of designing, new construction and reconstruction, which can be ecological and can influence positively on opportunity of conversion of Moscow to sustainable development:

- Ecologization of general layout of city.
- Ecological reconstruction of existing buildings.
- Ecological reconstruction of existing plants.
- Ecological reconstruction of existing engineering structures (highways, railways, etc.).
- Environmentally safe construction, conservation and rehabilitation of landscapes in city at building.
- Designing and construction of energy - saving and energy - active buildings.
- Guaranteeing of healthy and beautiful architecturally - landscape medium, which cultivate love of inhabitants to city.
- Designing and construction of resources- saving buildings, ecological solution of a problem of waste.
- Designing and construction of biopositive (ecological) engineering structures.
- Conservation and reduction of life medium.
- Rehabilitation of high-quality ecological infrastructure.

The problem of sustainable development, restoration and conservation of life medium on basis of ecological infrastructure is very important for Moscow (fig.). Medium of life in Moscow is rather polluted; only small part of its territory can be recognized as conditionally clean [1]. Therefore acceptance of "Program of sustainable designing and construction of Moscow" and "Program of conservation and restoration of life medium" are very actually. The stated below program was make by author and was published in materials published by

city administration to conference on sustainable development of Moscow [2]. However it is not accepted officially hitherto.

Approach of city to sustainable development and ecological compatibility can be estimated by the following criterions:

- Is maintained the ecologically well-founded relation between built up and natural territories?
- Are sufficient the ecological corridors, is supported the biological variety?
- Is maintained ecologically well-founded density of inhabitants?
- Is maintained ecologically well-founded area of nature around city?
- Is provided the satisfaction of basic needs of inhabitants?
- Is beautiful architectural - landscape medium of city, love inhabitants their city?
- Minimizes the city its global negative influences (minimization of usage of energy and resources, reduction and exception of waste and pollution)?
- Minimizes the city its regional influences (pollution of aqueous basins, rivers, air, ground, etc.)?

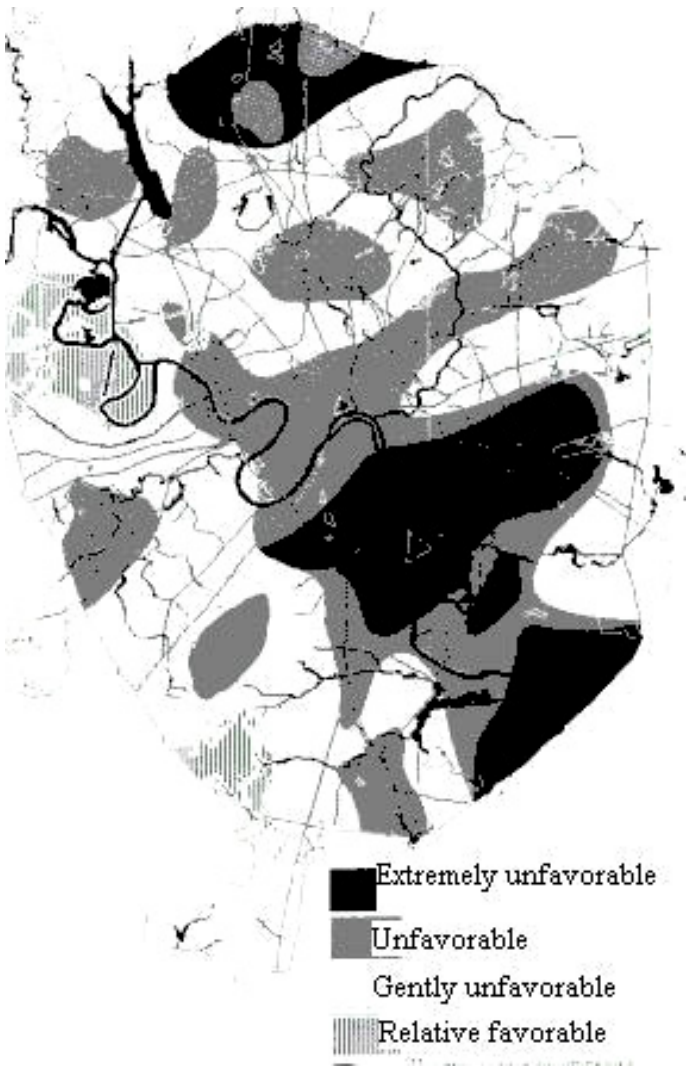

Figure. Ecological condition of Moscow.

- Provides the city presence of multiform and extensive natural territories for animal and plants?
- Gives the city to each man of wide opportunities and wide choice for realization of his needs?
- Is adapted the city to convenient, pleasant, quiet, healthy, sustainable life of each inhabitant; provides the city of opportunity for fixed contacts of its inhabitants?
- Provides the city equal opportunities for different ethnic, age, cultural, professional and other groups?
- Is the city self-regulated structure upcoming as complex system and reacting to changes with the help of direct and feedbacks ties? Interrupts the city natural streams of matters and energy?
- Provides the city presence of sufficient vital space for each inhabitant?

- Are sufficiently ecologically all kinds of life and activity of man in the city (transport, industry, energy complex, etc.)?
- Are ecologically all solutions of buildings and engineering structures? Is maintained the soil-vegetable stratum from building?
- Provides the city ecological education of its inhabitants and creation of new ecological ethics by new urban and architecturally - building solutions?

"Program of sustainable designing and constructions" includes the following parts:

1. Sustainable ecological general layout.
Making norms of designing of ecological and sustainable reconstruction of existing city and its districts, norms of designing of ecological and sustainable new general layouts of all levels.

Ecological adjustment of general layout of Moscow. Making of network of "green corridors". Complete usage of underground space for organization of depots, garages, parking, etc. Transfer in underground space of all plane objects (parking, auto plants etc.), and different plants of Moscow. Transfer of most unecological objects from city. Making of extensive parks in districts of city with sites of "wild" nature and with fructiferous gardens for production and addition of biohumus, worked out from bio-waste. Making of network of bicycle tracks and foot tracks that are not cross with motor transport. Collecting of rainwater from hard pavement for secondary application. Organization in centers of districts ecological centers of formation and education.

2. Creation of system of restoration of wide ecological infrastructure in city and around city.

3. Sustainable mastering of underground space, building of underground city.
-Norms of designing of wide complex of underground buildings and structures.
-Program of transfer in underground space of wide complex of buildings and engineering structures, first of all in city center.
-Program of transfer in underground space of railways in city with making on their place of radial "green corridors".
-Program of transfer in underground space of well-founded quantity of intense highways in central part of city.
-Examination and development of design solutions of underground buildings of wide assignment.
-Development of economic stimulus of encouragement of underground placement of buildings and structures at competitive designing.

4. Sustainable architectural solutions of buildings.
-Norm of reconstruction of old building and erection of new districts, buildings and engineering structures taking into account their fullest ecologization, norm of designing of new ecological buildings, engineering structures, blocks, districts.
-Development, designing and construction of pilot buildings with ecological architectural solutions.
-Development and expansion of use of low high-density building (building not higher than trees (up to 6-7 levels); the first level - as a rule, - workshops, shops, cafe, overlying levels - inhabited locations; roofs - lawns).

-Investigation of solutions with wide usage of shall construction as shapes, most similar to natural forms (use of sense ecology).
-Development, designing and construction of energy-active and energy-saving buildings.
-Choice of locations of inhabited buildings taking into account exception of ill effects of electromagnetic fields of ground (away from geo-pathogenic zones) and other harmful fields;
-Gardening of horizontal and vertical surfaces; introduction in decoration of buildings of elements of national art, wall painting.

5. Sustainable design solutions of buildings and engineering structures.
Norms of designing of constructions of ecological buildings and engineering structures - apartment houses, industrial buildings, engineering structures. Making of norms of designing with increase of reconstruction and reduction of new construction.

Development, designing and construction of buildings and engineering structures providing conservation of soil-vegetable stratum, clearing and restoration of natural medium: overhead - underground buildings, underground buildings and building on complex territories, biopositive and multifunctional, "clever" objects.

Buildings with planting of greenery of roofs, vertical planting of greenery of walls, with attached winter gardens in level 1-2 levels or on roof.

Complex of ecological engineering structures – of retaining and noise protected walls, overpasses, roads, bridges, etc.

Development of solutions on ecological reconstruction of existing buildings and engineering structures instead of new construction.

6. Sustainable power consumption.
-Making of norms of designing stimulating saving of energy and usage of renewable sources, making of norms of designing of energy-active buildings.
-Making of norms of energy-saving reconstruction of buildings.
-Development, designing and usage of energy-saving architectural and constructive solutions of buildings.
-Development, designing and application of energy-active buildings and engineering structures with a substantiation of opportunity of usage one or several sources of renewable energy: solar, wind, geo- and hydrothermal, bio-energy.
-Development and mass application of prime expedients of energy-saving reconstruction: energy-saving reconstruction of walls, windows and roofs, controllers of heat on everyone heat battery and counters of heat, passive solar heating and summer cooling, energy storage, salvaging of interior heat, individual boiler-houses.

7. Sustainable consumption of materials.
-Making of norms of designing with saving of building materials.
-Making of norms of designing on usage of principles of building bionics and expansion of application of spatial constructions.
-Development of norms on encouragement of application of local and renewable materials.
-Maximal usage of natural and not harmful to man materials, available in quantity and traditional for region.

-Encouragement of usage of materials, which can be recycled to greatest degree (or repeatedly utilized) with minimum losses, after performance of its functions, at reconstruction or dismantling.
-Development of norms of designing, lengthening terms of operation of buildings and structures.
-Investigation and expansion of application in construction of renewable materials, or widely presented in earth cortex.
-Expansion of application of harmless materials from waste of industry and construction.

8. Sustainable landscapes and planting of greenery.
-Making of norms of designing permissive to maintain and to reduce natural landscapes and their components, to support biovariety, to raise fastness of anthropogenic landscapes.
-Norm on phyto-melioration and permaculture of city.
-Sustainable planting of greenery both phyto-melioration of city and eco-blocks; high coefficient of planting of greenery; special selection of kinds of trees, bush, grass with the purpose of the most productive clearing of air both rain water and entering in air of curative phytoncides.
-Making of the most aesthetic and bioproductive landscapes.
-Planting of greenery of all accessible for this purpose horizontal and vertical surfaces of buildings and engineering structures (roofs - lawns, walls - lawns, noise-protected and retaining walls - lawns, fencing, street lamps); making of system of care of this greens.
-Creation on small part of territories of blocks of fructiferous garden and kitchen garden, where acts compost and humus from apartment houses.

9. Rising sustainability by support of dialogue, connections and equal opportunities on quality of housing and service of inhabitants.
-Making of new norms of designing of blocks and dwellings, in which relations of inhabitants are encouraged with help of architecturally - planning measures, their equality and team-work on making sustainable city is supported.
-Creation of comfortable closed courtyards, free from vehicle. Separation on height of sidewalks and streets.
-Construction in districts of city of halls of public assemblies (theatres), ecological centers of formation and education with video halls, libraries, small zoos, aquariums, terrariums, greenhouses.
-Making of common networks of collecting both clearing of waste and rain waters in one block and common plants for utilization of bio-waste and production of bio-humus guided on fertilizer of ground of garden (park) in center of block (of district of city).
-Making of joint networks of usage of renewable energy.
-Making of common block systems of differentiated waste collecting with insert of separate rooms in composition of buildings.

10. Sustainable water consumption.
Making of norms of designing providing economical expending of water and its reuse, and also usage of rainwaters. Collecting and usage of rainwater from roofs (after clearing - as drinking water). Collecting and usage of rainwater from pavements (after clearing - for watering of green plantings, outwash in toilets). Collecting and reuse after clearing waste household waters from baths and kitchens (for watering of greens, outwash in toilets), organization of underground tank of water for block.

Organization of small centers inside blocks on preparation, usage and clearing of all water inside blocks (center of recycling of all water in eco - block). Organization in this center of structures and devices requiring a higher water consumption - of basins for float, clothes washers for all block etc.

Placement in underground space under this center of tanks of water, devices of deep clearing of effluent and small clearing of rain water.

Usage of easy means of saving of water: counters, washbasins with small section of tubes, shower bath instead of baths, taps with low water expense etc.

Usage of third thin tube for drink water supply with small expense of very clean water.

11. Sustainable transport.

-Making of norms of designing stimulating a foot motion and cycle, public electric transport and transport "in tube". Encouragement of public transport not polluting environment or ejecting small pollution, mainly of electric transport (in underground tube - such as subway).
-Separation of levels of automobile and foot streams with purpose of exception of their cross, reduction of accidents, local clearing of pollution.
-Encouragement of foot motion (organization of special network of paths which are not crossed with transport ways, with planting of greenery).
-Encouragement of cycling, organization of network convenient cycle paths and foot roads, parking.
-Placement of parking of personal transport on boundaries of blocks, without travel inside blocks; organization of moving pavements on loaded sites.

12. Sustainable system of waste.

-Making of norms of designing of system of minimization, differentiated collecting, salvaging and ecological storage of waste of city. Making of system of minimization, collecting and salvaging of all solid household waste and their complete recycling.
-Development and realization of designs of ecological and architecturally expressive urban dumps closed by soil bed and gardening after filling.
-Designing of apartment houses taking into account of system of separation of waste at collecting on combustible, utilized (paper, glass, metal, plastic etc.) and worthless (only last go on dump).
-Development of devices for composting of organic waste and their usage for obtaining bio-humus - fertilizer for gardens and park in one block (district).

13. Clearing of air, ground, water; restoration of their conditions.

-Making of norms of designing of buildings both engineering structures taking into account clearing and restoration of natural properties of air, water and ground.
-Development of system of clearing (restoration of properties) of air in city with help of complex of measures, including architecturally – building means.
-Development of system of clearing (restoration of properties) water in city with help of system of measures, including architecturally – building means.
-Development of system of clearing (restoration of properties) of soil-vegetable stratum in city with help of system of measures, including architecturally – building means.

14. Augmentation of role of natural technologies, erection of perspective buildings.

-Making of norms of designing permissive to use natural technologies in series of functions: in cooling, in clearing of air and water, etc.
-Designing of system of usual both perspective ecological buildings and engineering structures and of ecological technologies which are in system of ecological education. Designing of separate completely ecological objects and eco-blocks, included in system of ecological formation and education.
-Allocation of sites in territory of city and eco - blocks for erection of new types of perspective ecological buildings: for example, completely energy independent houses, energy-active buildings, buildings with attached vertical hothouses from southern party, buildings with complete salvaging of interior heat, overground - underground apartment houses (all surface of ground is not occupied by building, except columns), active - biopositive buildings with clearing of air and water through all surfaces contacting to air and earth water.
-"Clever" (intellectual) buildings with self-acting tracking for state of health of people and state of all home systems and maintenance of normal state of health and of state of home systems and economy of energy and resources.
-Buildings with natural technologies not requiring energy consumption (for example, technology of cooling), etc. Buildings with completely closed cycles of vital function, independent of urban networks.

15. Making of city, sustainable, beautiful and favorite by all dwellers.
Making integrated and harmonic, ecological both beautiful city and its blocks, bringing up inhabitants by ecological and beautiful architectural medium.

CONCLUSION

It is very difficult to frame healthy and clean sustainable city from usual megalopolis with set of all pollution. The making of sustainable and healthy city is possible only on the basis of the systemic permanent program including ecological formation and education of all principals of city, designers, architects, and inhabitants**.**

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Architecturally - building ecology as part of sustainable building - most important science of 21st century for guaranteeing of sustainable development of cities

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Why it is very important to create sustainable biopositive cities? Why it is important for modern architects and civil engineers to know the architecturally -building ecology and ecological infrastructure for support and preservation of life medium? This position of principle does solely actual problem of making the healthy cities. Making the sustainable biopositive cities is connected with the conservation and restoration of the whole natural environment and, consequently, of life on the Earth. Essential principle of sustainable eco-city creation is ecological balance of nature with city. This science and its usage will allow creating sustainable healthy cities and settlements, to stop retreat of nature, and to achieve a state of sustainable development. The healthy and sustainable cities can become the most major achievement of mankind during all its history [1-3]. The nature recedes under anthropogenic influence, and for restoration of ecological balance and natural environment the researchers offer only one way: it is necessary to reduce the area of the anthropogenic changed and built up territories, to return a significant part (about third of used territories) "mastered" and polluted territories in natural condition. Such return is impossible at observed growth of urban territories and increase of number of mankind. In my opinion it is possible to replace this return by sustainable construction, ecologization of territories, sustainable bio-positive reconstruction of places of location, buildings and engineering structures, that will allow creating essentially new bio-positive objects, allied to nature, not polluting nature and included in natural ecosystem. The nature will perceive these bio-positive objects (buildings, engineering structures, settlements, country) as natural objects, which gradually will result in achievement of stability, restoration of the broken balance and exception of deviation of nature under anthropogenic pressure of the mankind. Architecturally - building ecology and ecological infrastructure will allow to receive not only reduction of ecological equilibrium, but also high quality of life in future ecological sustainable cities. If such result will be received, it will allow considering this new science - architecturally - building ecology, and results of its application in practice of construction, the highest progress of mankind. Therefore new science should be taught in all highest architectural - building educational universities.

There is in this course the fundamental content of new branch of engineering ecology – architecturally - constructive ecology. It is the science about ecological, healthy, sustainable and beauty cities. There are in architecturally - constructive ecology two complexes of ecology knowledge's: complex of general ecology knowledge that allows forming an ecological thinking of architects and builders, and complex of special ecology thinking for ecologization of building. Complex of general ecology knowledge includes learning about biosphere and ecosystems, learning about eco-cycles and anthropogenic influences, data about ecological postulates (theorems) and their connection with construction, and modern data about sustainable development of city, sustainable designing and construction. The special knowledge includes

all necessary knowledge - from biopositive building fundamentals and earth surface preservation to ecological restoration of existing cities and erection of ecological cities (eco-cities). There are in special knowledge ecological architecture and urban ecology.

Architecturally - building ecology is reinforced and deepened by new course – "ecological infrastructure" [4]. This course is devoted to major problem of modern town-planning both construction - conservation and improvement of ecological infrastructure as basis of conservation of healthy medium of life of person and ecological basis of environmental engineering of territories. There is in this course new conception of ecological infrastructure as broadest complex of natural, natural - anthropogenic and artificial objects and systems providing requirement of conservation of medium of person's life (environment of person). Medium of life of person is dynamical aggregate of interactive among themselves completely natural environment, quasi-natural cultural medium - cultural landscapes etc., substantially artificial technical medium of cities, socially - psychological and socially - economic medium.

There are in this course "ecological infrastructure" ways of ecologization of traditional infrastructure - complex of economic and cultural objects and branches composing underlying cause of productions (including industrial and social infrastructure). The author has included in the ecological infrastructure all natural medium (which is unmade support itself), natural resources and requirements of life of society. The ecological infrastructure of country includes aggregate of natural, including registered territories, nature protection and environmentally safe buildings and structures, plant and establishments, warning and liquidating unfavorable natural phenomena and social discomfort. There are description of problems of maintenance of ecological equilibrium of anthropogenic and natural territories, ecological framework of territory; ecological corridors; technological systems of ecological infrastructure in connection with ecological safety. Knowledge of ecological infrastructure allow to create ecological framework of city, green corridors, quality of life in cities, eco-blocks and apartment houses giving high quality of medium of life, conservation of soil-vegetable stratum, ecological restoration of landscapes and ecological reconstruction of all buildings and engineering structures. It is possible to use factors of meta-infrastructure including nonrenewable and renewable natural resources, ecological building materials, renewable energy, and energy – saving, energy - active buildings.

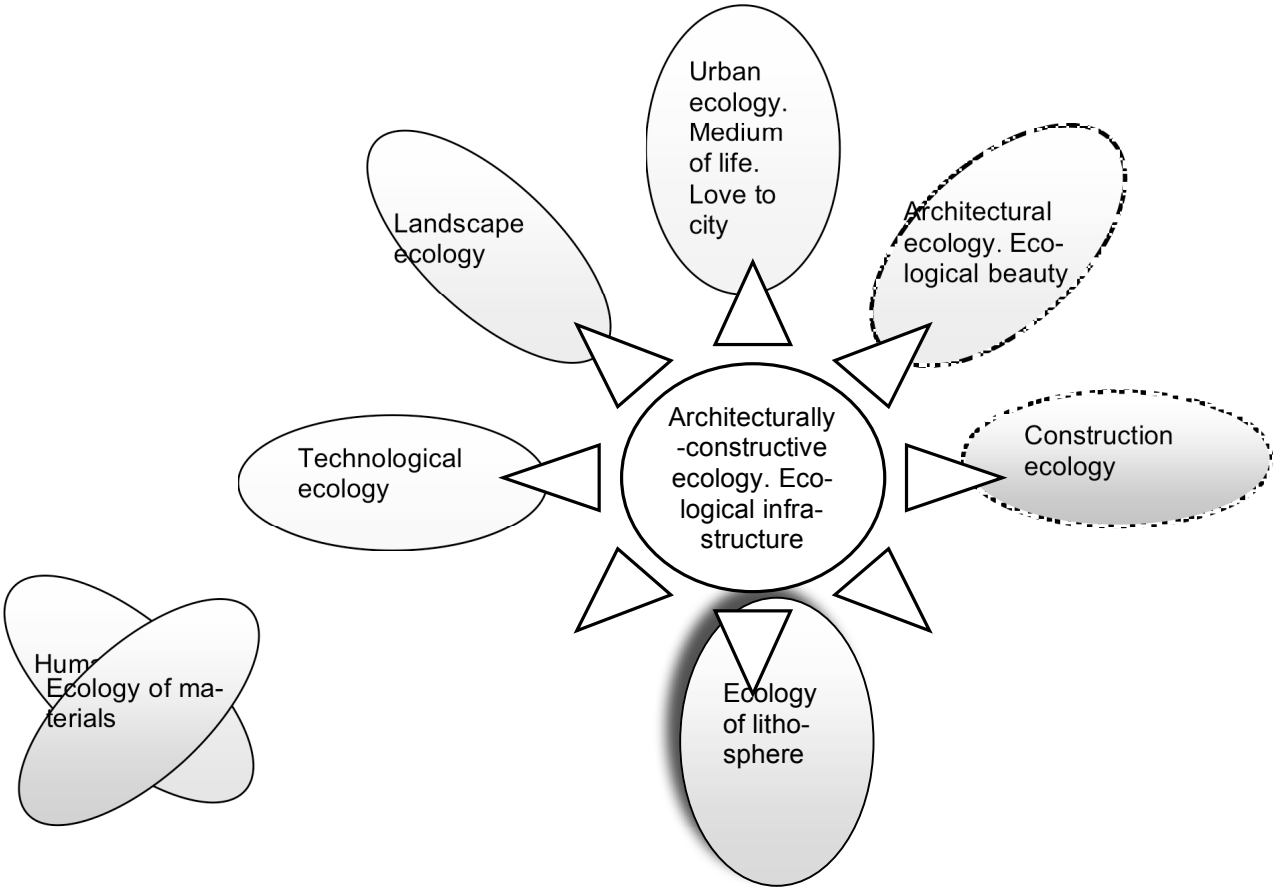
There are in new sciences 5 basic principles of ecologization [3-5]:

a. The most important principle is the principle of iso-ecology (of equivalent substitution). This principle has the following meaning: any artificial objects (a city, a house, a street, etc.) substituted a part of natural environment by itself fulfill along side with the main functions those functions which substituted functions of natural environment fulfilled (for example, to produce biomass, oxygen, to purify air and water, to allow or no to interrupt natural circulation of matters and energy, to let niches for biota, to introduce only processed waste in the volume that in replaced environment, etc.).

b. The principle of ecological biosphere compatible (eco-adaptation): all artificial objects or technologies must be adapted to environment. They don't destroy a flora and fauna, must use a natural renewing matters and energy, must save a matters and energy, must self-decompose and self-destroy after realization of their functions with return of elements in natural circulation or works process; they don't interfere in landscape, etc.);

c. The principle of nature image, deep bio-analogy (all city techniques and technologies are similar to natural objects and technologies). There are eco- and biotechnology, they don't pollute a nature and must give a minimum of waste similar a waste in biosphere cycle. An analogy must be deep; it must be founded on profound study of construction and function of natural objects. They don't bring harm to nature and don't use nonrenewable natural resources. Buildings and structures must be "soft" and "clever" objects and must self-react on various external influences, must create a high quality of life.
d. The principle of ecological support, eco-restoration of nature (bio-restoration): all buildings and structures provide for the restoration of nature with human existence and activity. They help to return formerly seized matters and energy, to create new "anthropogenic" deposits of minerals, to save high quality energy.
e. The principle of eurhythmic (beauty, harmony, proportion with nature); all artificial objects are in harmony with landscape; they conform to sizes of landscape elements and to man sizes; their form are founded on use of natural forms. The healthy city must contain new buildings, structures, techniques and technologies with application of principles of biopositivity. All buildings and structures allow coexisting a total of living organisms. Special constructive measures serve for guarantee of their life.

The architectural - building ecology is wide area of applied ecology, organically connected practically with all sections of theoretical and applied ecology. Thus, the architectural - building ecology consists of a number of organically connected among themselves and interpenetrative each other of sections. Frequently same problems are considered in different sections, thus the purpose and depth of their consideration varies a little. On the basis of this approach we offer structure of architectural - building ecology:



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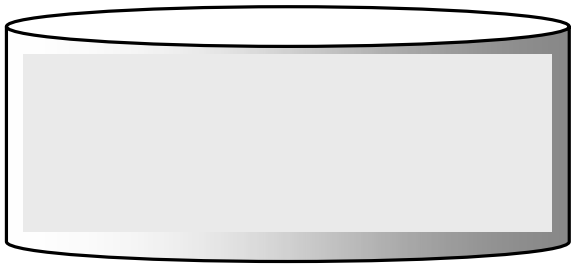

Figure. Structure of architecturally - building ecology

Both courses serve the purposes of education of the architects and builders (first of all of students, and also engineers) in area of ecologization of cities, sustainable designing both construction, and conservation of healthy medium of life. The architect and engineer - builder as the basic participants of process of creation of environment of man should represent, how cities and buildings will influence on environment and on animate nature, how natural environment will cooperate with artificial environment. Knowledge of laws of development of nature, ecological infrastructure and architecturally -building ecology, will be help to exclude negative influence of buildings and structures on nature, to enter them organically in natural environment, to support development of natural systems and simultaneously to increase quality of life. In this connection we shall formulate tasks of architecturally - building ecology [3-5]:

1. Creation of ecologically beautiful and healthy urban environment, including environment inside buildings;
2. Study of features of interaction of natural environment and places of moving (including all kinds of human activity in cities) and development of ways of ecologization of this interaction in view of equal of environmental space, maintenance of sustainable development of settlements;
3. Sustainable designing and construction, maintenance urban, architecturally - ecological and building-ecological means of ecological balance between cities both natural environment and sustainable development of cities;
4. Increase of quality of life in cities and apartment houses by ecologization of life and activity of man in city, ecological restoration of natural environment, approach by natural environment, phyto-melioration, creation of attractive image of city, soft interaction of city with natural environment;
5. Ecological optimization by help of sustainable urban- and architectural planning, design, technological decisions in view of exception of negative influences on an environmental nature and restoration earlier broken environment, restoration of anthropogenic landscapes;
6. Use of ecological buildings and structures, and also town-planning, architectural, constructive, technological decisions perceived by natural environment as related to it objects and included by it in ecosystem, assisting to existence, restoration and development of natural environment;
7. Ecological reconstruction the earlier built cities, separate buildings and structures.
8. Economy of all resources, their sustainable consumption, and use in the greater measure of renewal resources, reduction and exception waste, with the purpose of achievement of sustainable development at equal environmental space for all countries;
9. Application of natural and similar to nature ecological materials, and also ecologically admitted (ecologically allowed, ecologically allowable) waste of manufacture at manu-

facturing building materials and products with the purpose of exception of receipt waste in an environment;
10. Forecasting and estimation of possible negative consequences of construction, operation new and reconstructing of cities, buildings and structures for an environment;
11. Timely exposure of objects, prejudicial to an environment, through ecological-economic monitoring, and acceptance of the appropriate decisions;
12. Ecological certification of materials, products, buildings, structures, with the purpose of revealing them ecological compatibility for cities;
13. The periodic analysis of movement of city to the greater stability of development and to ecological compatibility by comparison of the previous and current meanings of indicators of sustainable development.

Eco-city and eco-blocks serve for inhabitants and for nature. Basic decisions for eco-city and eco-blocks creations are: 1. Sustainable general plan. 2. Sustainable architecturally - constructive decisions of buildings. 3. Sustainable engineering structures. 4. Sustainable energy. 5. Sustainable use of materials. 6. Sustainable industry and transport. 7. Sustainable use of water. 8. Sustainable system of waste. 9. Cleaning, recycling, restoration of quality. 10. Greenery and bio-production. 11. Guarantee of inhabitant's intercourse, equal possibilities in dwelling quality and inhabitant's service. 12. Actions for biodiversity preservation (niches for animals). 13. Love to city education and sense ecology. 14. Examination of perspective ecological decisions and ecological education. 15. Inhabitants participation in building.

The basic problems considered with sustainable constructive and technological decisions of buildings are creation of such designs and technologies, which would allow:

1. To not tear away of ground, suitable for agricultural, recreational use, creation of reserved zones and sites of a natural alive nature, for the purposes of construction;
2. To not close or to close minimally surface of ground to not create below surface of ground of impenetrable screens to not interrupt natural evaporation, movement of storm and earth waters, to not interfere with activity of animals in ground;
3. To return in natural condition sites of territory after ending term of operation of a building and its disassembly, and also in process of reconstruction as a result of displacement of objects in underground space;
4. To plant trees and gardens all outside surfaces of walls and roof (thus are best for using natural substratum); to use soil filled volumes inside walls and between buildings for creation of the connected among themselves files of a ground on a building and under a building;
5. Maximum "to enter" buildings in landscape; to use spatial designs at new construction and at ecological reconstruction as much as possible meeting the requirements of visual ecology; to apply principle of miniaturization in buildings and in technologies (for example, individual boiler-houses instead of large central, etc.).
6. To utilize all waste, to save up energy and water, to use sources of renewed energy, to make buildings by independent from external networks;
7. To make buildings or structures adapted for existence of animate nature; to create substratum and shelter, which would be adapted to the requirements of animals and plants to place them habitat;

8. To create buildings, structures and whole complex - area, cities - with achievement of condition preservation of natural environment, perception by its natural environment as natural component included by nature in its ecosystem.

Complex of general knowledge contains information from general ecology, conceptional ecology, and global and deep ecology assisting to understand interaction of man and nature in architecturally - building activity. The modern representation about ways of ecologization of activity of man and sustainable development of cities is formulated on last global ecological forums spent UNO. There is in this material gradual reorientation of thinking and activity in the advanced countries in direction them ecologization. The connection between ecological decisions in construction and appropriate decisions in nature is shown; the history of development of the ecological decisions in construction is given.

The contents of urban ecology, architectural ecology, building ecology is given in complex of special knowledge. The wide complex of environmentally safe and regenerative decisions in construction is given - since of ecological region (country), of the ecological general plan of city and finishing by separate biopositive (ecological) buildings and basic engineering structures - retaining and noise protected walls, streets and highway, fences and posts of illumination, sea shore protected structures. There is ecological reconstruction of unecological earlier constructed objects - separate buildings and engineering structures. There is a modern conception about sustainable designing and construction, about beauty of buildings and cities, about features of ecological beauty are given.

The course "Architecturally - building ecology" contains information on ways of control and quality management of urban environment, data on ecological examination and sanitary - ecological certification of new and existing objects.

Author of this report within 10 years taught and teaches this course in higher educational universities of Ukraine and Moscow. For this time author published the manuals and monographs, which helped the students to study a new science more deep. The students with major interest are engaged in learning of new course and design ecological buildings. First hand of teaching has shown, that the new educational course is very important for ecologization of thinking of the students and for learning by them of practical expedients of ecologization of cities.

I have been going often by electric train in Moscow center. Each evening in Moscow on stations I have been seeing paupers, homeless, alcoholics, outcast by the society of people, and amongst them are the children. Simultaneously I see new buildings for rich, "elitist" building and village, in which live a rich people behind high fence. Newspapers are filled by the advertisement of elitist, rich houses and apartments. In Moscow prospers an installing the steel doors, steel lattices on windows, different signalizing on doors, on cars. Apartments become to look like permanent military fortifications. Alarmed cars chirp instead of birds in the night on streets. Many urban decisions directed on disassociating the inhabitants. In such city sustainable development is impossible. City must not separate its people, as it is presently. To reach a sustainable development of city, people must act together.

Architecturally - constructive and urban deciding must encourage contact of inhabitants and bring up them in the ecological attitude. It is needed to inculcate in inhabitants a love for its

city. But can love its city poor, outcast person, living in bad conditions in the distance from good and clean region for rich? Secure tenure in the city with strong social stratification is impossible. Problems, with which pushed mankind, are very complex. On the first place, on our opinion, stands ecological and human upbringing and education. First - a correct thinking, then - correct actions. Hereinafter is a decision of most broad complex of problems - from the social ecology to the human ecology, from the urban ecology to healthy city creation, from love for the city to the maintenance of contact of equal inhabitants, etc. Such there should be remarkable role of new science.

CONCLUSION

New conceptions of architecturally - constructive ecology and of ecological infrastructure as broadest complex of natural, natural - anthropogenic and artificial objects and systems may help to create healthy medium life in sustainable cities. Ecological reconstruction of old cities and ecological restoration of polluted landscapes on base of architecturally -building ecology will help to create sustainable healthy cities.

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The Influence of Urban Microclimatic Conditions on the Heating Energy Demand of Dwellings in Lisbon

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1. INTRODUCTION

The local climatic conditions within a city, which affect building energy requirements, depend on the physical characteristics, shape and situation of each element of the urban landscape, in addition to the general climatic conditions of the zone. Essays for characterizing Lisbon climate had already been performed by Alcoforado (1988). The present study is concerned with the interrelationship of energy consumption for heating purposes and urban climate.

Buildings and human activity also affect microclimate. Therefore, urban climate and urban built environment are strongly interrelated. Increased urban temperatures have a direct effect on the building energy consumption for winter and summer periods. Prediction of building energy demand for the Lisbon urban environment, for both periods, is the main objective of the present study situated in the framework of a research project entitled, "Building Environment, Urban Climate and Rational Use of Energy". A similar study, by Santamouris (1998) and Asimakopoulos et al (2001), was carried out in Athens, between 1996-1998. This study was done during the summer time in order to analyze the impact of heat islands on building energy consumption. The present paper will discuss a methodology for how this question was addressed in Lisbon (Portugal) but for winter period.

2. URBAN STATIONS IN LISBON

In order to evaluate microclimate conditions in Lisbon city, nine urban stations (relative humidity and air temperature) were used as located in the map presented in Figure 1. Station locations were selected to be representative of natural topologies as well as of different urban morphologies. As such, Stations 8 and 9 are close to the Tagus River while Stations 1 and 4 are near an area of dense vegetation, Monsanto Park.

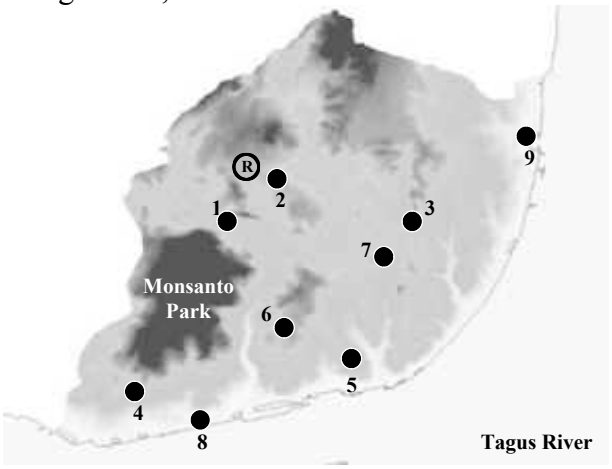

Figure 1 Urban stations locations and reference station (R) at INETI Campus.

All the stations were placed in residential urban areas, and when it was possible, close to buildings in the south facade. Buildings are implanted in different urban morphologies as synthesized at Table 1.

Table 1 Sensor placements and urban morphologies.

Station No.	Location	Environment urban morphology	Vegetation	No. of floors	Facade orientation
REF	INETI Campus	Campus	high	2	Roof
1	Benfica	Villa	high	2	South
2	Telheiras	Square	medium	2	South
3	Areeiro	medium density	low	4	South West
4	Restelo	Villa	high	1	West
5	Bairro Alto	high density	low	4	West
6	Campo de Ourique	medium density	low	4	South
7	Praça de Londres	square	low	7	South
8	Belém	square	medium	1	South
9	Parque das Nações	medium density	low	5	South

During the 41 days of winter (November 18th - December 28th), relative humidity and air temperature were monitored at all stations. Additionally, diffuse and global radiation as well as wind intensity and direction were measured at the INETI campus station. During the study period, mean air temperature values reached 10.4 ºC at the reference station, minimum and maximum mean values ranged from 7.2 to 14.9 ºC. Integrated global and diffuse solar radiation values were 85 and 29 kWh/m^2, respectively. Winds were primarily from the northeast with a mean value of 0.6 m/s. Focusing on night air temperatures – as collected from 8 pm to 8 am - at the urban stations, temperatures were systematically found to be between 0.5 (at Station 1) and 1.8 ºC higher (at Station 9) when compared with the ones recorded at the reference station. Those differences are presented in Figure 2, by average and standard deviation values as well as by heating degree-days for a basis temperature of 18ºC. As expected, the heating degree-days (HDD) values were lower at the urban stations, with differences from the reference station of between 11.6 (Station 1) and 39.5 (Station 9).

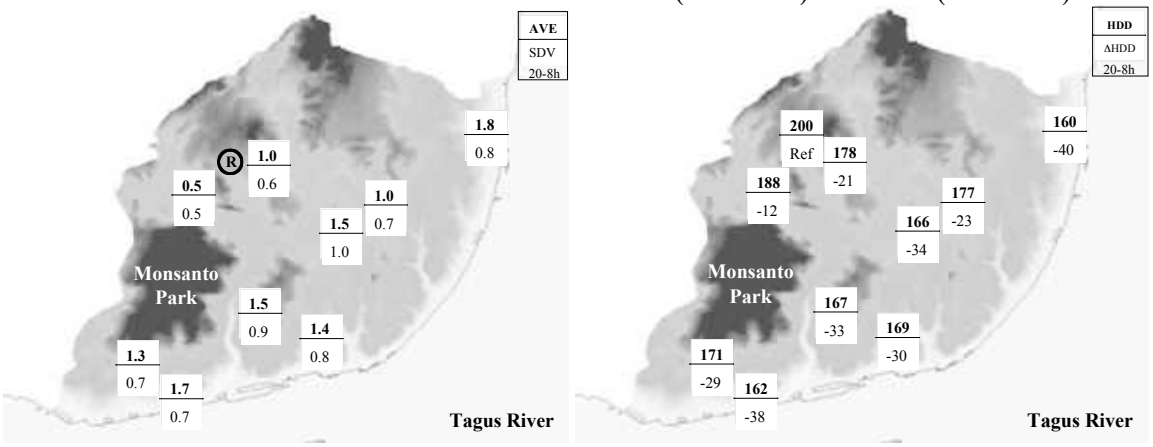

Figure 2 Night temperature differences and heating degree-days at urban stations.

3. SIMULATION METHODOLOGY

3.1 Base conditions

Two reference models were simulated in order to represent a unit of a typical apartment building and of a single-family house. Both models have the same floor area (174 m^2) and a glazing area of 26 m^2, 70% having a southern exposure.

The single-family house model represents a three floor attached house, with external south and north facades. East and west walls connect to zones with similar thermal conditions. In this model six thermal zones were defined: two zones in the first two floors, one facing south and the other north, an unique zone in the upper floor and one crossing the three floors corresponding to the stairs.

The flat model typifies an intermediate floor with only two external walls. In this model, only three thermal zones were defined: two zones, each one facing one of the main orientations, and a buffer zone between them.

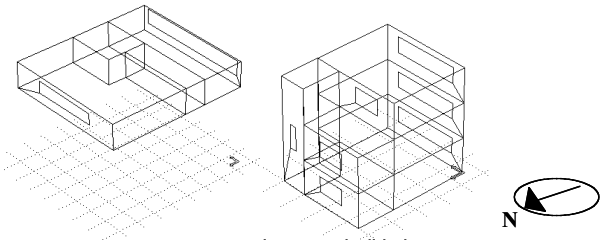

Figure 3 Building thermal models.

The constructive solutions adopted for the basis conditions are described in Table 2 and were selected because they still can be used according to the actual Building Portuguese Thermal Regulation for the Lisbon climatic region.

Table 2 External building envelope solutions and U-values.

Envelope element	Description	U (W/m^2 ºC)
Roof	hollow brick elements and insulated concrete layer	0.6
Wall	brick + air gap + brick (11 + 6 + 11 cm)	1.4
Window	6 mm single clear glass (SG)	5.4
	6 mm single clear glass with roller shutters	2.7

3.2 Parametric Studies

The parametric variations were performed replacing double brick wall with an insulated (INS) one and single (SG) with double glass (DG). These solutions are pointed toward in the future Portuguese Building Thermal Regulation for the Lisbon climatic zone.

Table 3 External building envelope solutions and U-values.

Envelope element	Description	U (W/m^2 ºC)
Insulated Wall	2 cm insulated double brick (11 + 11 cm)	0.8
Window	Double glass (DG) (6 + 6 + 6 cm)	2.8
	6 mm double glass with roller shutters	1.8

4. RESULTS

4.1 Air temperatures and discomfort degree-days (free-floating)

Using hourly climatic data measured at the reference and urban stations, simulations for the two models were performed for the period between November 18th and December 28th. The thermal behavior of the two models was numerically simulated by ESP-r (2000). The hourly simulation results' analysis consists of the comparison of internal conditions of each model at the nine urban stations with the corresponding model at the reference station (INETI Campus). Higher external night temperature values, observed at the urban stations, attenuate the decreasing of night temperature values inside the dwellings. This fact, at each urban station and for all the zones of each model with different external envelope solutions, can be evaluated by the total discomfort degree-days (DDD) at a base temperature of 18ºC as well as by the hourly indoor temperature values.

Figure 4 (left side) presents the decreasing of heating degree-days calculated for each urban station compared with the reference station (HDD=200). The reduction in heating degree-days, from Station 1 to Station 9, is accompanied by a decreasing of discomfort degree-days inside the models' zones. Figure 4 (right side) shows the discomfort degree-days reduction values, for one south zone in the apartment model and for the single-family house model as well as for the three parametric variations applied to each model, when compared with the reference station model. The local influence becomes less decisive for the apartment model with a more insulated solution (double glazing and double brick insulated wall). Differences obtained for the apartment model range between 5 and 10 for single glazing solutions and 2 and 3 for the double-glazing solution. For the single-family house model, there are no significant differences among constructive solutions; reductions vary between 5 and 14.

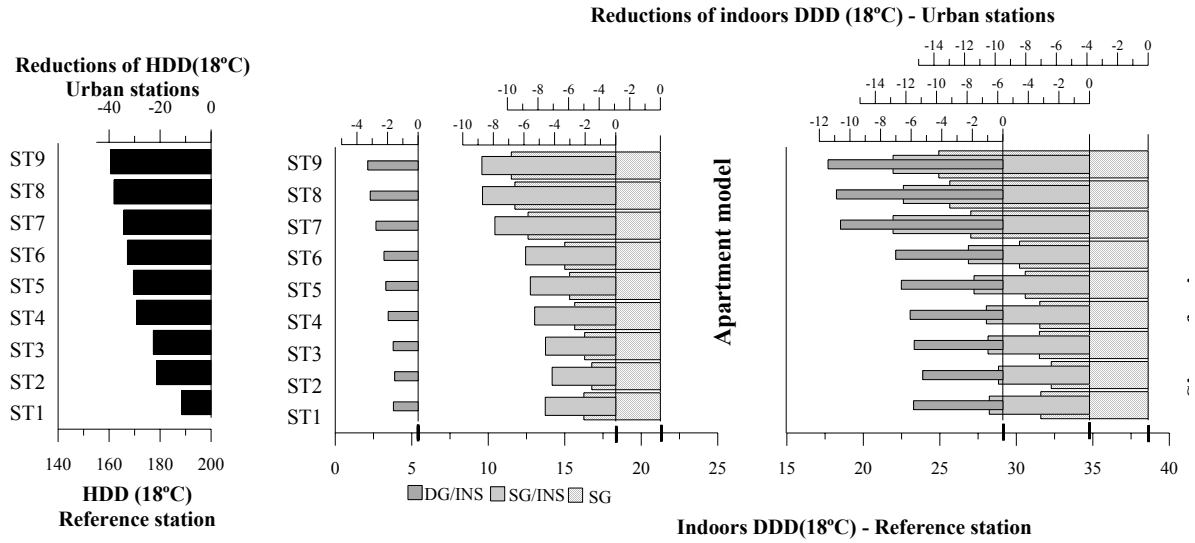

Figure 4 Discomfort degree-days for different solutions at the urban stations as compared with the reference station.

Hourly night temperature differences were obtained for each urban station, comparing air temperature values with the ones collected at the reference station. The frequency distribution of those differences for the three urban stations is presented in Figure 5. The highest differences were observed at Station 9, where external night temperatures were 1.8ºC higher, causing an increase of 1.2ºC inside the house. At Stations 2 and 6, differences of 1.0ºC and 1.5ºC reflected an increase of 0.6ºC and 0.8ºC, respectively. The distributions presented in

Figure 5 refer to outdoor and indoor temperatures of the apartment model south zone with single glazing and no insulated external wall.

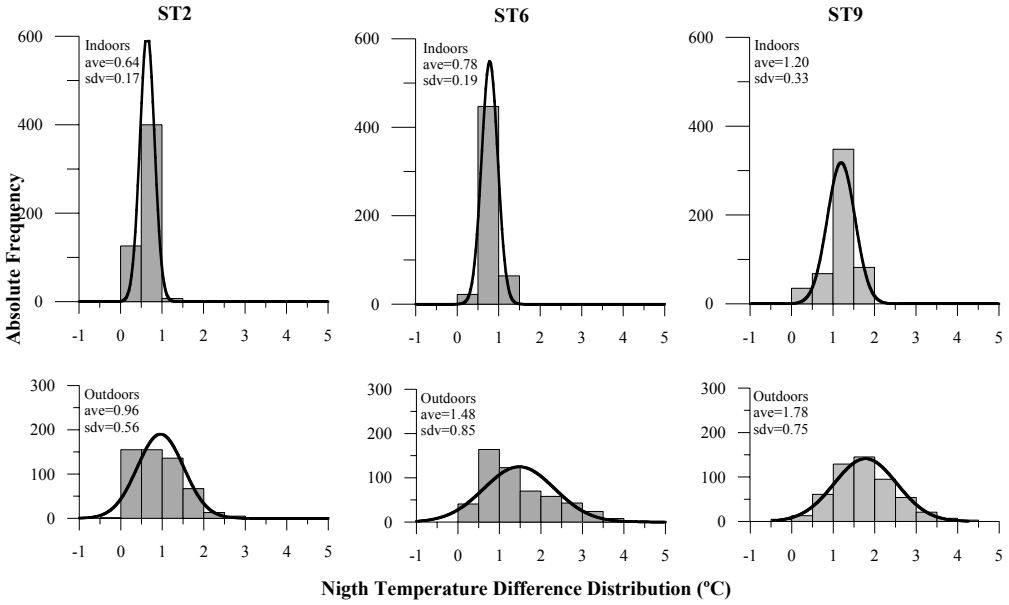

Figure 5 Comparison of indoor and outdoor night temperature values at the urban stations and at the reference station.

4.2 Heating energy demand

With the data of the climate conditions obtained from the reference and urban stations, simulations were run with an ideal heating system set at 18 ºC in order to determine spatial variations of the heating energy needs of each model.

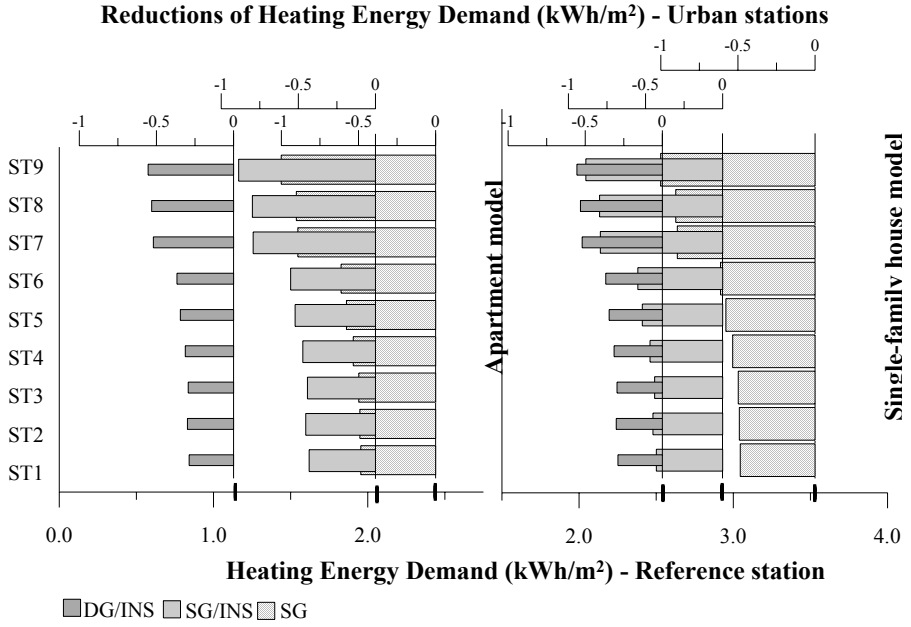

Figure 6 Heating energy demands for the different solutions at the urban stations as compared with those from the reference station

The bottom axis of Figure 6 corresponds to the heating energy demands at the reference station while the top axis corresponds to the reduction obtained by changing the model location (from the reference to the urban stations). Despite apartment and single-family house

models having different absolute energy requirement values, energy reductions are similar for both models at each urban station. Table 4 presents the reduction values obtained for the various models at three stations.

Table 4 Reduction on heating energy demand related to the reference station.

Station No.	Night Temperature Difference (ºC)	Model	Constructive solutions - energy reduction (kWh/m^2) SG	SG/INS	DG/INS
2	+1.0	APT	-0.5	-0.5	-0.3
		SFH		-0.4	-0.4
6	+1.5	APT	-0.6	-0.6	-0.4
		SFH		-0.5	-0.4
9	+1.8	APT	-1.0	-0.9	-0.6
		SFH		-0.8	-0.7

At Station 9, increasing the urban night temperatures to 1.8ºC produced a decrease in heating energy demands of about 1.0 kWh/m^2 in the single glazing and no insulated external wall solution. The double glazing and insulated external wall solution is less affected, with reduction values of 0.6 kWh/m^{2}and 0.7 kWh/m^2, for the apartment and the single-family house models, respectively. Energy demand at Station 6, which presents night temperatures 1.5ºC higher, is 0.4 to 0.6 kWh/m^2 lower than the corresponding reference station model. Models at Station 2 have energy demand values 0.3 to 0.5 kWh/m^2 lower than those of the reference station.

5. CONCLUSIONS

This study points out the interrelationship of heating energy demand and urban climatic conditions in Lisbon city. The experimental results collected during this work confirmed that the external night air temperatures in built-up urban areas are higher than those found in the countryside. Furthermore, proximity to the Tagus River appears to affect the decreasing of the night air temperatures. Simulation results, applied to the 41-day period of winter, quantified the influence of night temperature differences on heating energy demand for the different models investigated. Night temperatures 1.8ºC higher were recorded at the stations closest to the Tagus River. These temperatures translated to reductions of from 0.3 to 1.0 kWh/m^2, compared with absolute values from 1.1 to 3.5 kWh/m^2, depending on the building typology and constructive solution. These results show reductions on the overall heating energy consumption (14 - 31% apartment, 20 - 49% single family house) for different urban locations. More insulated solutions are less influenced by spatial climatic differences.

To evaluate the overall impact of high urban temperatures on the global energy demands in Lisbon, it would be necessary to extend this study to include the summer timeframe and increase the number of air temperature and humidity stations involved. Future experimental work will focus on these aspects.

ACKNOWLEDGEMENTS

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Promotion of Sustainable Buildings in China
Integration of Bamboo and Renewable Energy Technologies

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INTRODUCTION

Conservation of natural forests is a key issue in China's sustainable rural development. One of the problems in rural China is the use of large quantities of wood and red bricks in house construction. So is the extensive use of firewood as the fuel for space heating and cooking. This causes destruction of forests, and the consequent water shortage and soil erosion problems. The annual consumption of fuel wood accounts for some 60% of the total forest consumption after commercial logging was banned in 2000.

With the increase in living standards in rural areas, demand for housing is growing. So is the market demand for high quality and attractive hotels for tourists. Another market is also important. Majority of the school in the Southwest regions needs to be rebuilt and the government is to invest more than 1.5 billion RMB for the development of schools over the next few years. Construction of ecologically friendly schools will improve the living environment for teachers and students, and help increase their understanding of renewable energy applications and the concept of sustainable development.

The scarcity of traditional forest wood resulting from conservation oriented management practices, and constraints associated with the acquisition or use of non-wood materials have attracted attention on the need to find suitable substitutes. In this context, use of bamboo has emerged as an ideal material.

BAMBOO

Bamboo has a long history as a building material in many parts of the world. It is light, strong and it can grow quickly and sustainable, even on degraded land. In addition, it has the potential for creating employment opportunities for the rural poor, in particular for women. Bamboo can therefore address three major global challenges:

- Livelihood security (generation of employment through bamboo plantation and primary processing for manufacturing mat-based composites and other products)
- Ecological security (conservation of forests through timber substitution, efficient carbon sequestration, alternative material to non-biodegradable and high embodied energy materials such as plastics and metals).
- Sustainable food security (bamboo based agro-forestry systems, maintaining the fertility of adjoining agricultural lands, bamboo shoots).

A large portion of the rural housing in Asia, Latin America and Africa is constructed from bamboo. In recent years, the use of bamboo in popular housing construction has increased because of the cost and scarcity of other building materials. In Central America, for example Costa Rica and Ecuador, technology has been developed for the construction of low-cost, safe and durable bamboo housing that can withstand earthquakes and typhoons. It is reported that in Limon, Costa Rica, only bamboo houses from the national Bamboo Project stood after the violent earthquake in 1992. Quality bamboo housing has become socially acceptable in many parts of the world, especially in Latin America (Ecuador, Colombia, Costa Rica) where large-scale public housing program exist. In the last two decades, the imaginative research has encouraged the use of bamboo both for structural and decorative uses.

China has abundant bamboo resource, available in 18 provinces and regions. Bamboo is an important resource to substitute for wood and forest products. It is cheap and locally available. There is a big potential for its wider use as a building material, particularly in Southeastern and Southwestern China. Promotion of bamboo as a building material will have the following benefits: reduce wood consumption and the pressure on forests; limit the use of red bricks as building material; low-cost for the rural poor, a new model to combine energy savings and renewable energy technologies in buildings with wide use of bamboo; provide employment opportunities in rural areas; and stimulate bamboo resource development and industrialization. It also has other social benefits such as reduction of health effects of wood burning in traditional rural houses.

ENERGY-EFFICIENT BUILDING PROGRAM WWF

In China, the concept of sustainable building development is in the early stage of development and is not widely known to the general public. In some regions in China, there are abundant renewable energy resources, such as solar, wind, small hydro. To promote wider use of these renewable energy resources will help promote sustainable rural development, and reduce the dependence on fossil fuels burning, which is the main cause of global warming. The main challenge is how to use these resources and related technologies cost-effectively, and at the same time, to preserve local traditional and cultural heritage. Social acceptance of sustainable building development is the key to success.

The buildings and houses will be bio-climatically designed with the concept of passive solar house and installed with solar thermal water heater, integration of solar PV system, and micro wind turbines if local resource is available in order to utilize solar energy resource more efficiently, particularly in cold high mountain areas. Biogas technologies will be used to utilize the wastes from the humans and pigs. Other energy saving measures will also be used to be adaptable to local climate conditions, such as the use of natural cooling measures and other techniques. Water saving measures will also be used to conserve water and minimize environmental impacts of wastewater discharge.

The key concept of this project is to link energy savings and the utilization of renewable energy technologies with the use of bamboo and bamboo panels as the main building material when appropriate. The WWF "Panda house" logo, together with INBAR logo will be used in all the buildings/houses, and in communication and media promotion activities, and commercialization with the involvement of property developers and local governments. Through communication campaign, wider use of energy efficient bamboo buildings and houses will be promoted.

WWF China (www.wwfchina.org) and the International Network for Bamboo and Rattan (INBAR) (www.inbar.int) have jointly launched the project "Promotion of Energy Efficient Buildings: Integration of Bamboo and Renewable Energy Technologies" in March 2002. The objective of the project is to design model houses, hotels and school buildings for rural people in southwestern China, particularly in Yunnan Province where abundant bamboo resource is available and has a tradition of using bamboo as building materials. Because of the climatic variations in Yunnan, the design and construction work should take into consideration of different local conditions and use the available resources in cost-effective perspectives.

As part of the project, a joint field visit to Baimaxueshan, Jinghong and Honghe of Yunnan Province has been made. With the local officials it was decided to design/ build the following prototype energy efficient buildings:

1) Tibetan Community School in Baimaxueshan
   Phase 1 will be a school for 50 students (6 – 12 years). Phase 2 will be an extension to 150 students. The construction of the school should be completed by October 2003.
2) Energy-efficient house for the Dai ethnic group, Jinghong.
   A typical Dai-style house (100 m2) has to be designed that meets modern comfort and requirements. The same knowledge can be used to improve the existing Dai houses without changing the cultural heritage. Important is the typical roof style with clay tiles.
3) Energy-efficient hotel in Dai style, Botanic Garden in Xishuangbanna
   The plan is to build a tourist's hotel (50 rooms) within the Botanic Garden in Xishuangbanna. Bamboo and bamboo panels will be used as decoration building materials. The use of bamboo floor is considered appropriate.
4) Energy-efficient house for the Hani and AXi, Honghe
   Main difference is between houses in the valleys (warm) and in the mountains (cold). This can be seen in traditional architecture as well. Mountain houses are mainly made of clay. Valley houses use more wood (less thermal mass).
   The house will be around 100 m2. This is based upon clay / brick walls and use of wood and bamboo.
5) Energy-efficient School in Pingbian.
   The elementary school will be for 200 students and 14 teachers. Construction shall be started in October 2002 and complete in May 2003.

The design of buildings/houses will be jointly made by BEAR Architects, the Netherlands (www.bear.nl) and the Urban & Rural Planning & Design Institute of Yunnan Province, China, taking into consideration of local climate, economic, social and cultural conditions. Dutch bio-climatic and solar architect, Tjerk Reijenga, from BEAR Architects, the Netherlands is key expert in the project. Detailed designs of the above buildings will be completed by August 2002 and the construction completed by 2003.

CLIMATE CULTURE AND TRADITION.

As China is located on the southeastern sector of the Eurasian continent towards the Pacific Ocean, air masses of either continental or maritime origin will affect its climate. The monsoons represent the overwhelming climate and weather regime for China, which govern the climatic conditions throughout the year [16]. In general, winter monsoon from mid-Siberia and Mongolia brings cold and dry air masses to China during the winter period; summer monsoon from the subtropical anticyclone in the Northwest Pacific and the cross-equatorial flow from the southern hemisphere generates precipitation and warm weather during the

summer period. The two distinguished monsoons together create large differences in seasonal climatic conditions.

The province of Yunnan is mainly located in the Warm Climatic Region. This means that the coldest month average temperature is between 0 and 13 °C and the hottest month average is between 18 to 25 °C. The days with a daily average temperature under 5 °C is between 0 and 90 days a year.[1][2] Local conditions are strongly influenced by altitude and prevailing wind. Altitudes in the province of Yunnan differ between 500 and 6000 meters. The main plateau around Kunming has an altitude around 2000 meters.

The province of Yunnan has diversity in nature and in culture. About 25 of the 56 minorities in China can be found here. This is the only province were Han Chinese don't have the majority. Because of the mountains, transportation and communication were difficult. These circumstances resulted in independent ethnic groups with their own culture and architecture. Some of the main styles of traditional residences are: bamboo pillar or stilt houses, wood log houses and the adobe (mud) houses. The influence of Han Chinese is visible in the brick courtyard houses or the One-Chinese-Seal house.[3]

1) The pillar or stilt house. [picture 1]
   Very characteristic are the pillars or stilts that are made from wood or bamboo. The living area is on the first floor, high above the ground.
   Main construction is bamboo. Nowadays a lot of pillars are made of wood.
   People live on the floor and don't use furniture.
   The reasons for such a house are periodical flooding of the river, the mostly sloping terrain, to avoid disturbance by animals and the people has the habit to live on the floor.
   The house is well-ventilated and shaded inside and outside. The space under the house is used for animals, working space and storage.
2) The wood log house.
   This house is built with wood logs with their typical construction details in the corners of walls. The roof is made of wooden shingles.
   The reason for such a construction has to do with the easy access of wood in that region and the easy construction. The houses are flexible and strong and can resist earthquakes and animals. Wooden tiles keep in very good shape also with very low temperatures.
3) The adobe (mud) house. [picture 2]
   The basic structure is wood or a combination of wood and adobe brick. The adobe brick is covered with a layer of adobe to get a smooth surface.
   In the west of Yunnan (Tibetan area) the houses are made from rammed earth and painted white. [picture 3]
   Houses have in general two or three (partially) stories. The ground floor for livestock, the first floor for people and storage. If there is a (partial) third floor, this floor is also used for storage.
4) The One-Chinese-Seal house [picture 4]
   The structure is based on the traditional Chinese wooden post and beam frames. The house is regular and symmetrical organized around a courtyard. In different areas are different variations in materials and ground plan layout. The house is a combination between the local architecture and the traditional Han architecture.[3] Materials used are wooden post and beams, rammed earth, adobe or ceramic bricks and ceramic tiles.[4]
5) The 'modern' style

Today many traditional materials are replaced for glass, aluminum, steel and concrete. Ceramic tiles protect the concrete outside surface. This style can be seen from the north to the south of China. These buildings are not responsive to local climate and culture. For that reason most houses need an air-conditioner to survive the house.

New designs have to respond to the local climate and the culture. Wood is used for fuel (heating and cooking) and as building material. Because of the shortage of wood and the protection of forest it is necessary to build energy-efficient and to use other more sustainable materials. This is a great opportunity for the use of bamboo products.
In traditional villages it is necessary to improve the quality of living with respect for history, nature and culture. The new architecture should be climate responsive like the traditional architecture. Other aspects are sanitation and economics. Both has to be improved and can work together to make houses more energy-efficient.


Fig. 1. Typical house in traditional Dai style


Fig. 2. Typical adobe house in traditional Hani style.

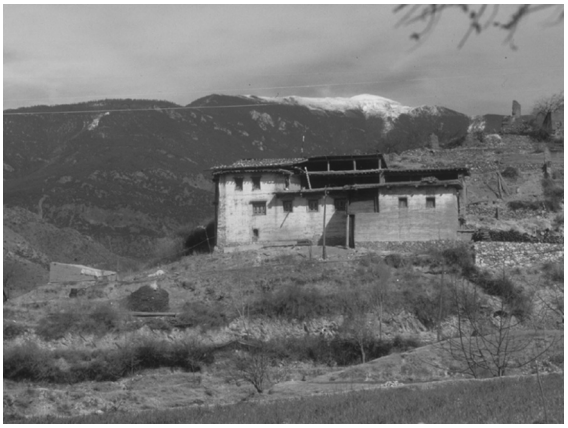
Fig. 3. Typical adobe house in Baimaxueshan.


Fig. 4. Typical One-Chinese-Seal house

The modern cities have a more divers architecture. The traditional architecture is a source of inspiration and knowledge. New designs should learn from tradition and climate responsive. Mechanical installations like HVAC can be avoided or made more efficient by the bio-climatic design of buildings.

AN ENERGY EFFICIENT BIO-CLIMATIC APPROACH.
The different local climates give completely different circumstances for every project. In the west part of Yunnan Province, heating, passive and thermal solar will be the most important

issues. In the southeast part the main topic will be passive cooling. Some of these areas will have a small heat demand at night.

Sanitation has to be improved and the combination between toilet, biogas installation, live stock (pigs) and a greenhouse can also improve the income of farmers. In the west of Yunnan province these combinations can be seen on a small scale. The quality of the greenhouse has to be improved to last longer. Especially the plastic covers sheets. Sources of energy for household energy use will be biogas (for cooking) and solar thermal systems for hot water.
The principal of passive cooling and heating means in summer: minimise heat gain and maximize heat removal. In winter it means: maximize heat gain and reduce heat lose.

The energy efficient Dai house will use passive cooling. This will be done with the following strategies: ventilation during the day, night ventilation, earth cooling and solar cooling.

To demand for cooling will be reduced by: building layout and orientation, window size and location, external sun control and shading, evaporation around the building and efficient daylight without heat building (indirect lighting or optical systems)

On higher altitudes, with big temperature drops at night, thermal mass will be particularly beneficial. Where mass is used for warmth, it should be exposed to incident solar radiation. Buildings may be pre-cooled using night-purge ventilation (opening the building up to cool breezes throughout the night), although this requires significant amounts of exposed mass, and may be necessary only at certain times of the year.

In cooler areas on higher altitudes heating demand is the main question, Because of the high amount of sunhours, passive thermal solar energy is very appropriate.

TIBETAN COMMUNITY SCHOOL IN BAIMAXUESHAN (28°N, 99°E, ALT. 2690 METERS)
The south facing sloped site is part of a Buddhists holy place. The school is designed as 2 buildings around a courtyard. The courtyard is closed on the East Side and open to the West Side. From here, one has a good view on the Buddhist village and temple of Dongzhulin. The east part of the site and the slope on the north will be planted with trees to protect the school against the cold eastern winds.

The two buildings are built in the slope in a way that all educational functions are around the courtyard. Heat from the classrooms will go up and warm the floor of the dormers. A glassed corridor in front of the dormer rooms act likes a solar collector and keeps the heat inside. Kitchen and dining room are on a lower level and the upper training room, offices and bathrooms will gain heat losses from these rooms.

The passive solar design has large south facing windows, roof top windows and smaller north facing windows for extra daylight. Solar thermal panels are integrated in the roof and the heated water is used for radiant floor heating and domestic hot water. Auxiliary heating is done with biomass. Some greenhouses and a biogas installation are used for growing food and natural gas for the kitchen.

Phase 1 will be a school for 50 students (6 – 12 years). Phase 2 will be an extension to 150 students. The construction of the school should be completed by October 2003.

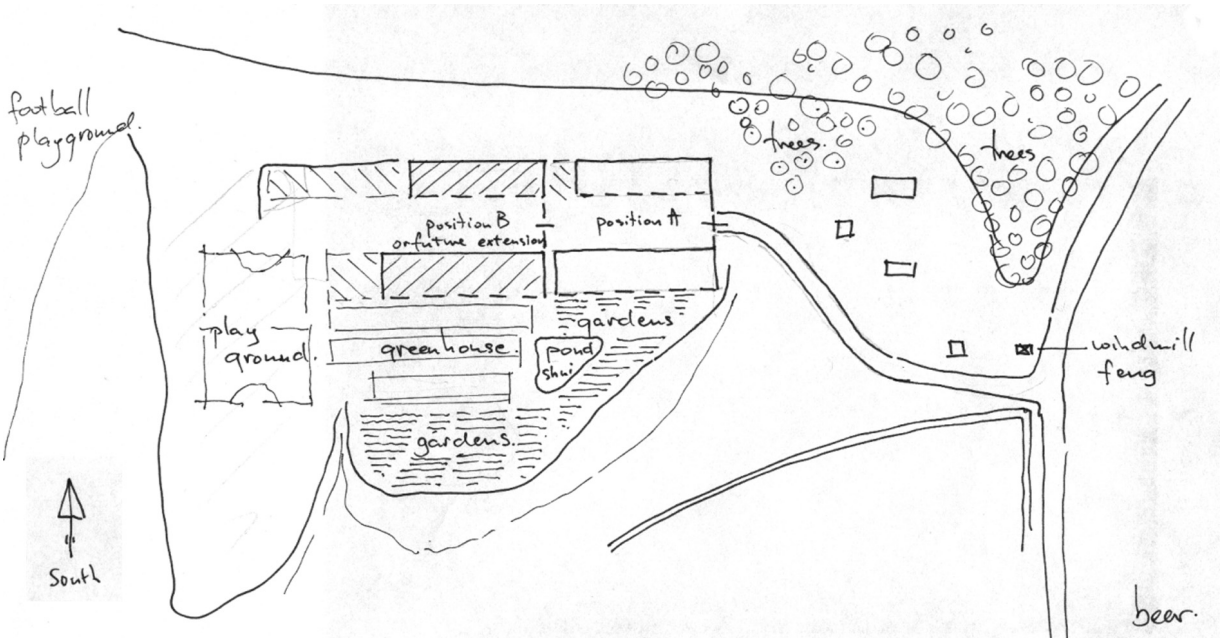

Fig. 5. Site lay-out for the Tibetan Community School in Baimaxueshan

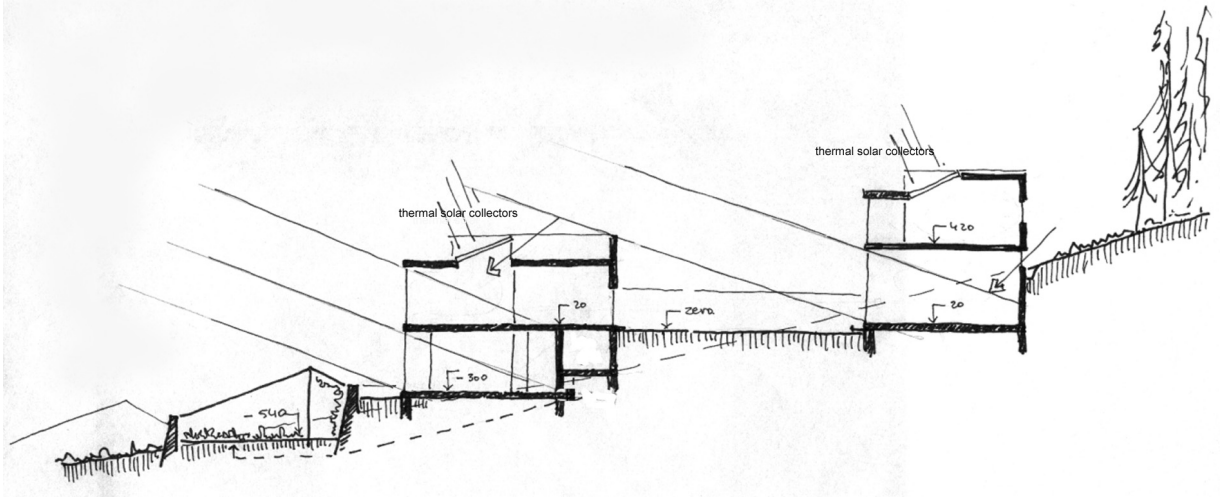

Fig. 6. Cross-section on the school with solar and daylight features.

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Built in 2020
Futuristic Pictures and Stories for Tomorrow's Building

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1. INTRODUCTION

In the new millennium far-reaching socioeconomic changes will take place in western societies. New technological developments, changing leisure-time activities, increasing mobility and new forms of employment will have massive effects on living and building of tomorrow. Sustainability may therefore not refer only to the building and its construction in the narrowest sense, but considering also social, cultural, economic, or political developments. How will potential forms of living and building look in the year 2020 having regard to expected socioeconomic trends for the future? Will certain societal developments counteract the improving eco-efficiency of technological developments in the building sector?

2. APPROACH

Its central theme being the future of residential construction in Austria, the project "built in 2020" (Walch et al. 2001; *http://www.iswb.at/openspace/gebaut2020*) analysed the multitude of existing information about trends and prognoses for "western" societies – for everything from lifestyles to technologies, from demographic developments to tomorrow's refrigerator. Basic socioeconomic assumptions for Austria were derived from former projects (ARGE SU2 1998, arge@motion 2000). The results of this comprehensive trend analysis were complemented by numerous qualitative interviews with a large variety of experts, ending in the presentation of a multifaceted vision of the future, a scenario especially for the Austrian living and building, called "built in 2020".

3. TRENDS IN BUILDING AND LIVING

The results of our trend analysis and its relevance for the building sector were structured within varying themes. The most important conditions for building of tomorrow are based on the following trend assumptions.

3.1 Our society will become older but remains active

Similar to other Central European countries, in the next 20 years great demographic changes are expected in Austria (Fassmann et al. 1996); the excess of age in society is one of them (Delphi Report Austria 5 1998). The group of people over sixty years of age is representing more than 25 percent of the total population by 2020 (Statistik Austria 2000). On the other hand, the percentage of children and young people is decreasing in number. As there is continuous growth in the number of elderly people, future buildings also have to meet the requirements of the older generation. Attractive living forms for this part of society will be a future market. However, the predominant image of elderly people has therefore to be redefined in the future, since agility and potential of this population group will rise due to increased life expectancy (Delphi Report Austria 5 1998).

3.1 Towards single-households: we live alone or with one other person

An outstanding fact is an enormous increase in households in Austria by 2020, although the population is not growing dramatically (Fassmann et al. 1996). This increase is mainly based on a "singularisation" trend towards an increasing number of households with only one or two persons. Consequently, the demand for residential buildings - and with it an additional demand for natural resources - will continue to increase by 2020; on the one hand due to the increasing number of households, on the other hand due to the still increasing average demand on residential space per person.

3.2 Still significant: we are born to move

In future we will live in a society where people are more mobile, not only physically, but also in electronic ways. Normal structures of time and space break up with information and communication technologies and, depending on the residence and type of work, may partly replace physical mobility (Faßler 2000). However, new economic structures, living forms in the countryside while working in centres, bad quality of our built environment and an increase in leisure activities, will result in an even higher mobility of life (Delphi Report Austria 2 1998).

Transportation systems will still be orientated around centres; agglomerations will be regulated with high quality infrastructure, whereas in the periphery, infrastructure will become under pressure, because of the population decline (ARGE SU 2 1998). This trend cannot be corrected by all the possibilities offered by information and communication developments; i.e., teleworking or homeworking.

3.3 We work longer and in new ways

With the development towards a service, knowledge and communication based society large-scale shifts in the job market are expected (Bauer and Bullinger 2000). Changing fields and forms of employment, flexible working hours and new working places will arise. But still many workers will come from traditional working professions, but with more flexibility of time and place (Horx 1999).

These changes influence the living and building of tomorrow. New technologies make working from home possible. Living and working will melt together. The labour market may not be the main driving force anymore for a choice of residence. But experts are not sure how fast these changes will take place (Walch et al. 2001).

3.4 More building technology for efficiency

Cost efficient technologies/systems, innovative housing technology, and in some parts environmental improvements in the building industry are expected for the next years (Delphi Report Austria 2 1998). The realisation of an eco-housing industry is subject to initiating more energy-efficient building technology and wider use of renewable ressources. Prefabrication and modular building components will increase especially. But also the importance of the TIME branches (telecommunication, information technology, media, and entertainment) will certainly influence future buildings, but only a few technologies are expected to broadly succeed, as only smart and simple technologies will be accepted by the average user (Horx 1999).

3.5 Trends in society and politics

The state steps back from influencing social processes, i.e., in the field of health or education systems (Delphi Report Austria 5 1998), and therefore it is expected for a new "civil society" to overcome this social distancing. Public subsidies in social housing will be reduced. As a

result, apartments will get more expensive, and the building industry is confronted with rising cost efficiency in construction and in maintaining the buildings.
The trend to individualisation in an increasingly competing society results in a more independent, but also a more self-sufficient, way of living for even more people (Horx 1999). Traditional families as the predominant way of living is replaced by multifaceted and individual lifestyles. Particularly the shift towards a dinki- (double-income-no-kids) and single-person-society (Delphi Report Austria 5 1998) is associated with an increased individual desire for social integration. Isolation and longing for new community living forms will therefore increase.

4. THE CONDITIONS FOR BUILDING OF TOMORROW

From above mentioned trends we derived a scenario "built in 2020" for building and living in the future. It is a multifaceted and multicoloured picture made up of various pieces which, when put together, form a whole. The main statement is that building of the future means variety. *One* building of the future does not exist, but a variety of "buildings of the future". We tried to express them with six types of homes (Walch et al. 2001). None of them offers a sharp image, but makes sociocultural statements regarding supposable forms of living and building in the future.

4.2 Built in 2020 - six futuristic pictures and stories

The *smart home* has an increased use of new technologies. But only smart and simple technologies are expected to broadly succeed. Matthias Horx, a German trend expert, talks about "KISS technology: keep it simple and stupid." Smart homes will develop in high quality of living, however, perfect smart homes will be affordable only for upper classes.

The *standard home* will be the equivalent of the standard home of today, but is defined much more by economic efficiency, since there will be a reduction of public subsidies in the next years. It will be the future middleclass building. High efficiency is the golden rule when building and maintaining a standard home.

The future increase in prefabrication in the building industry correlates to the *catalogue home*. With catalogue modules everything is possible; from single homes and family homes to new forms of cohabitation. There will be cooperation amongst similar industry sectors, like housing equipment. Housing will become an all-inclusive offer and will be affordable also for average income groups.

No homes will be the result of the future developments in society and politics. They are identified by virtual addresses and are completely new for housing trends. They arise with the new information and communication technologies in the world of new labour and new economy. Mobile homes, hotels, "hometels", new forms of hostels and community homes will come under the term *no homes*. Their location will probably be outside high quality infrastructure areas. The extreme form of *no homes* will represent disadvantaged people without physical or virtual addresses.

Low level homes will develop out of houses where people do not have the money for their maintenance. To this belong low quality suburban estates without quality infrastructure, urban islands with negative economic perspectives, and also single family houses from the end of the 20th century. These *low level homes* are far below the future standard home. High quality communication technology and other digital equipment will hardly be found. Socially disadvantaged classes will live in such homes.

The opposite of no homes and low level homes will be *without limits homes (wlh)*, the most exclusive way of living in the future. They will have the highest standards of housing and one can find them in most attractive places. Besides its exclusiveness, *without limits homes* are characterised by one feature; their formation cannot be forecasted, because they are orientated towards ultimate feasibility; they can therefore not be planned.

All these types of living and building were illustrated with collages and described by stories of life. The stories were written by our team as subjective tales. Based on the assumptions of the trend analysis and the scenario "built in 2020", the story-tellers describe the world and everyday life, focussing on building and living in the year 2020.

4.2 Sustainable building and living of tomorrow – a conclusion

Two rules for the future image "built in 2020" can be derived from these assumptions.

One is that the expected patchwork of lifestyles needs a patchwork of architectures and designs. The variety of lifestyles results in stronger plurality and individuality in the future. Sustainable residential forms of tomorrow have to reflect versatile and individual lifestyles. Flexibility will also be important in housing. Those apartments will be preferred which can be adapted to different lifestyles. Quality of life will be more and more defined by the quality of housing. This includes open spaces and the possibility for recreation and leisure in the residential area as well as access to modern infrastructure. In future, a stronger differentiation from today concerning offered products and services from the building industry is needed in order to supply the shifting market demand and contribute to social and economic aspects of sustainability.

The other rule is, that there will be in fact ecological improvements in future buildings. But what about sustainability? Environmental improvements are expected in the energy and material efficiency of a future building with less energy consumption, increased use of renewable resources and, in some areas, building materials with lower environmental impacts. Due to technical developments and the price competitiveness within the building sector, the average future building in Austria may achieve low energy standards or probably even passive house standards in 20 years. However, based on the previously mentioned socioeconomic developments, the average residential space per capita and the total number of residential buildings will continue to increase and probably over-compensate for these resource efficiency savings. Considering aspects like the entire lifecycle of residential buildings and their components, associated infrastructure and area needed, additional resource demand for a more and more global acting building industry transporting building materials over long distances, etc., it seems questionable if the field of building and living is able to improve its overall environmental performance by 2020.

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Residential Dreams
Quality Criteria for the Innovation-Oriented Housing Sector from the User's Point of View

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1. INTRODUCTION

„ ... but I have to go up. That is somehow an important thing for me. Half my circle of friends want to go straight out into the garden and I am the type who wants to look down from above. At first I thought that the big terrace was a waste, such a big terrace. But when my daughter comes with her 20 pairs of shoes, they all go outside, and her suitcase as well, and the children can play outside. So it's really very good to be able to put things outside. And I can look down from way up high. ...“
Rosa P., 70 years old, about her apartment on the 32nd floor

The exception proves the rule. But due to the conclusion reached from the project ”residential dreams” (Tappeiner et al. 2001; *http://www.iswb.at/openspace/wohntraeume*), we probably had a wrong picture somehow of "the rule" portrayed by experts. Extensive surveys and qualitative interviews with residents of new, innovative housing developments in Vienna hinted at the fact that the "average resident" with their widely accepted needs investigated by numerous market researchers, does not exist anymore.
We all know the old standards; about 75 square metres, three rooms, a terrace or balcony. And, of course, affordable. Perfect for a three person household. If there are no children, one can even afford a little office space. But how do the needs of residents look for the future? How would they like to live tomorrow and what would they do differently? Maybe the answer can be found by investigating the residents' satisfaction in so-called "innovative" housing projects.

2. APPROACH

Central to the project "residential dreams" are the motives for choosing an apartment and the needs of the residents of already existing innovative, multi-unit residential buildings. The aim is to encourage the acceptance of innovation-orientated housing by developing for investors and building developers criteria based on experience and fact, recommendations for action and suggestions for steps to be taken. The starting point for this is a detailed and targeted analysis with criteria for quality designed by the residents (SRZ 1996 a – d).

2.1 Comparative Cases

The analysed housing estates should not be built for the sole purpose of being "eco-buildings", but should meet sociocultural demands. They ranged, therefore, from a car-free housing development to a cost-saving DIY (do it yourself) project, and low-energy premises, to the highest residential tower in Austria. The five chosen reference projects were:

(1) Mischek Tower (1220 Vienna, contractor: Mischek GmbH)
(2) Low Energy House Engerthstrasse (1020 Vienna, developer: Vienna South)
(3) Thermal Housing Estate Oberlaa (1100 Vienna, developer: ÖSW)
(4) Self-built Housing Estate Leberberg (1110 Vienna, developer: GEWOG)
(5) Vehicle-Free Model Housing Estate (1210 Vienna, developer: GEWOG, Mischek GmbH)

2.2 Quantitative and qualitative analysis

The target of the survey in those housing estates was to establish the subjective criteria for residents´ choice of location, as well as the factors attributing to living satisfaction. In the year 2000 an investigation using 454 questionnaires was carried out in 5 Viennese innovative housing blocks which were subsequently analysed. The standardised questionnaire was in written form and was directed primarily at adults. For every multi-unit residential building there was one core questionnaire to which specific focal points were appropriate. One such questionnaire contained 37 questions on 9 pages to the following topics: (1) Motives for choosing apartment, (2) satisfaction with apartment, (3) overall assessment of the layout, (4) social climate, (5) mobility and everyday life, (6) wishes, and (7) housing in the future. Afterwards 22 qualitative interviews were carried out with residents of these apartments. Lifestyle aspects were especially considered during all interviews.

3. FINDINGS OF "RESIDENTIAL DREAMS"

The most important findings and statements of our analysis are summarised in the following five sections.

3.1 Housing happiness depends on location

One of the main results of this study strongly confirms the aims of a sustainable urban development policy:
No acceptance for a housing project can be found without good to excellent location. Deciding factors are therefore proximity to shopping infrastructure, attractive surroundings and easy access to workplace and recreational facilities. In urban areas this means accessibility to efficient transport systems such as subways, in the periphery it means easy access to bus and/or tramway which take you to a transport connection point.

The need to fulfil location criteria is - on the level of building itself - equivalent to housing criteria. These are layout, spaciousness, lighting, room climate, common/social rooms, garages and storage rooms, accessibility and an acceptable level of cost effectiveness. Of course, the building developer has to offer everything at a good „cost:value for money ratio". But where does that leave innovation as a deciding criterion?

3.2 Request for innovation?

Passive housing, participating housing, or high-tech living - innovation often pushed by leaders in the field of innovative housing are not easy to realise, as people looking for somewhere to live try to fulfil the aforementioned hard, almost conservative, criteria first. These needs clearly distinguish the market on a high level and are therefore the icing on the cake. To put it another way: all our efforts towards future-orientated housing are, even for residents of buildings designed for the future, only in addition to solid, traditionally-built housing. First the hard criteria of housing satisfaction have to be fulfilled, only then are other "softer" criteria considered by residents. But if so, innovative or other special features or even sometimes the colour of the façade can be deciding factors for similar offers: people looking for accommodation first gather offers of "similar" qualities, considering the location and cost:value for money ratio. Then they choose - according to individual needs and preferences

- the best and most convenient offer. The deciding factors could be then ecological features, impressive spaciousness, and social space, or efficient telecommunication access.

3.3 Town and countryside - a blur

Residents in remote areas are only partly satisfied with innovative and ecologically optimised housing. If residents are asked about their ideal residence, someone may receive a rather schizophrenic point of view: at the front there should be the subway, the working place, cinemas, theatres and shops; at the back the residents dream about walking through green meadows and forests, swimming in lakes and finding themselves face to face with wildlife. Therefore it is not very surprising to learn that about 40% of all urban residents in this survey name the one-family home in the country as their ideal residence. At the same time these people are above average satisfied with their current housing situation - the densely populated city area. The wish for an idyllic place somehow diminished when carrying out the interviews about quantitative issues: Yes to open space, but only if it is in the vicinity of urban areas.

3.4 „Housing" information task

An important responsibility of building developers and urban developers is for a transparent and direct information policy, which is directly connected to an education programme about housing. According to „residential dreams", the main tasks for information in the housing industry are:
(1) directness
(2) transparency
(3) hard facts & soft stories

3.5 Individual aspects for satisfaction

As mentioned before, the main factors for choosing a residence and being satisfied are „hard location criteria" and „hard housing criteria". Theme-housing, which has especially lately been strongly promoted at target groups, come second to the hard factors mentioned earlier. This is quite interesting as most of the housing developments involved in the study are housing projects with a fairly strong element of theme housing; urban living, car-free, skyscraper, do-it-yourself project, low-energy, thermal estates.
The findings of „residential dreams", however, should not lead to the wrong conclusion that there is no sense or place for target-group orientated forms of housing on the market. „Residential dreams" just proves the theory that there are prioritised, hard criteria in the housing market which represent the main conditions for high acceptance amongst residents.

Focusing on individual aspects of satisfaction in the form of theme-housing or similar (i.e., service orientation) could yield more possibilities for highly innovative housing projects with lifestyle orientated character. On the other hand, it should be clearly stated that no housing project with specific theme aspects can substitute the absence of the aforementioned „hard factors".

4. RECOMMENDATIONS FOR ACTION

The following recommendations can be made considering above mentioned conclusions:

4.1 Theme housing - target-group orientated housing

If a building contractor wants to take a project to the level of focusing on target groups and their satisfaction factors, they must put their focus clearly on the built-up environment (housing and open space). When acquiring customers on the housing market, this focus

should be clearly stated. Furthermore an detailed market analysis must be conducted by these contractors. This can be done through questionnaires regarding customer needs on application forms and interest lists in the contractor's office, or on a larger scale using different marketing techniques on site.
Subsidising innovative housing projects should therefore go hand-in-hand with a targeted higher qualification of target-group orientated housing. Through this it is possible to reach a high number of different housing types in times of individualisation and diverse lifestyles (Walch et al. 2001).

4.2 Flexibility is important

A very important feature of that list of topics is the question of flexibility of living space, and mobility. Up to now the need for flexibility has been largely addressed by incorporating flexible layout in the planning. The facility for changing existing structures is rare, although they should not be totally neglected. One aspect of ensuring flexibility, which has scarcely been considered so far, is a targeted push for mobility amongst the residents. The building contractors could act as key players in that connection if they consider the changing needs of the residents, more than they have up to now, as a service and also as a chance for promotion of their projects. More or less every building contractor owns empty apartments, which could be offered to residents who want a change, using them as apartment „pools" and promoting them with more drive. Administrative hassle, as with new customers is minimised (even the account number stays the same); teething problems with new customers can be reduced, these are only two aspects of the advantages compared to the acquisition of new customers. Pre-paid financial shares could easily be transferred to a new object. A contractor could even offer additional services, such as organising the move, and could therefore be considered as an overall service institution from an aspect of flexibility. The relationship between contractor and customer could become stronger resulting in a mutually lucrative „regular customer" relationship. For the resident it means considerably less hassle in looking for a new apartment and it increases the acceptance of, and satisfaction with, the contractor.

4.3 Service housing

The development of new services in connection with individual aspects of living lead to a new definition of the term "housing". Housing as a sum of individual satisfaction of needs, which are fulfilled by the formation of built-up environment and the offer of lifestyle and target-group orientated services. This needs innovative contractors (or independent agents) who offer their services in an extremely customer- and user-orientated way and are dedicated to developing them further.

4.4 Special case - periphery

For the majority of the participants in this survey a house in a green area is rated as their top wish - even when they are quite satisfied with the location of their present residence. This aspect of some king of schizophrenia on the market („urban life on the green meadow") surely represents a problem field.

5. CONCLUSION - ROSA P. IS THE RULE

Let's have another look at 70 year old pensioner Rosa P., who lives on the 32nd floor of the highest residential tower in Austria. Her needs seemed special for us, but were not exceptions in the survey. The project team encountered many Rosa's – old, young, with family or without, male, female – who were all exceptions and therefore became "the rule". All of them wanted their individuality, their own special housing needs. Of course - like everywhere else - mainstream needs could be seen too. One main conclusion that was most obvious for

the project team: A high quality housing market needs more diversity in the future. This is a difficult task in a society which is dominated by standardisation, especially in the building sector.

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Agenda 21 for Sustainable Construction in Developing Countries

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1. INTRODUCTION

Since the 1992 Earth Summit in Rio, when Agenda 21 was formulated as an international blueprint for sustainable development, all sectors of society have been in the process of interpreting and pursuing sustainability and sustainable development within their specific context. The ability to meet most of our basic human needs relate in one way or another to the creation and performance of human settlements. To address the role of human settlements in sustainable development, a second international action plan, the Habitat Agenda, was prepared. As the construction industry has a major role to play in terms of the sustainable development of human settlements, the need for an internationally agreed Agenda on Sustainable Construction was highlighted early on and the Interational Council fro Research and Innovation in Building and Construction(CIB) published its *Agenda 21 on Sustainable Construction* (CIB Report Publication 237) in 1999 after an extensive collaborative research process.

The CIB Agenda 21 was intended as a global intermediary between the international Agendas, and national/regional Agendas for the built environment and the construction sector. Its main objectives were to create a global framework and terminology that will add value to all national or regional and sub-sectoral Agendas and to provide a source document for defining R&D activities related to sustainable construction. The Agenda document provided a detailed overview of the concepts, issues and challenges of sustainable development and sustainable construction, and posed certain challenges to the construction industry. As the majority of the contributors were from the developed countries, the CIB Agenda 21 suffers from an understandable bias towards the issues, challenges and solutions of the developed world, and this is emphasised in the report.

However, creating a sustainable built environment in the developing world requires a different approach to that taken by the developed world and this is not often clearly understood and discussed. Not only are the problems and their scale, the development priorities, the capacity of the local industry and governments, as well as the skills levels often radically different, there are also certain cultural and worldview differences between the developed and developing world countries that impact on the understanding and implementation of sustainable development and construction.

Therefore, a special Agenda 21 for Sustainable Construction in Developing Countries was commissioned as part of the Action Plan for the implementation of the CIB *Agenda 21 on Sustainable Construction* and to further the CIB's pro-active approach on sustainable construction. Although the process is driven by the CIB, it is not a CIB exclusive project but a

participative process involving many other networks on sustainable human settlement development and developing countries, and is supported by UNEP-IETC.

The main objectives of this project were:

- To identify the key issues and challenges facing sustainable construction in the developing world, as well as the major barriers to practising sustainable construction.
- To identify a research agenda that focuses on possible responses to the challenges and needs of the developing world.
- To guide international investment in research and development in the developing countries.
- To stimulate debate and encourage the exchange of learning on sustainable construction within the developing world, thus drawing the developing world into the international debate as an equal partner.

2. THE PROCESS

The first step was to commission nine expert position papers, three each from Africa, Latin America and Asia. The authors were asked to comment on the following:

- The different regional understandings of sustainable construction.
- The issues and challenges facing the regions.
- The impact of the construction industry on the economy, the environment and society in the regions.
- The barriers to sustainable construction.
- The strengths and opportunities presented by the cultures and traditional practices of the regions.
- Suggested actions for the research community, governments and the construction industry.

From these position papers a First Discussion Document have been prepared. This document is available for comment on: http://www.cibworld.nl:600/pages/begin/A21SCDC.html [1]The contents of this document represent a synthesis of the nine regional position papers. Its purpose is to set the scene for discussions regarding the scope and contents of the final Agenda. To this end certain common issues, barriers, challenges and opportunities have been identified that the Agenda will have to address. The document also begins to suggest necessary actions by the various role players in the creation of the built environment.

The First Discussion Document has been used as basis for a broader consultation process. Using both workshops and the Internet to enable discussion, the consultation process identified the key priorities for action regarding the creation of sustainable built environments in developing countries, as well as concrete suggestions for the way forward. For each issue, key areas for action have been identified, with specific actions for different stakeholders. From this, the final Agenda was prepared and launched at the World Summit on Sustainable Development in Johannesburg, September 2002.

3. THE DEVELOPING WORLD CONTEXT

The developing countries have very different climatic, cultural and economic conditions, yet they have many common characteristics. The following are some of the main characteristics

[1] A full description of the project and participating authors can be found at http://www.sustainablesettlement.co.za

- The main sources of foreign income for most developing countries remain agricultural products and raw materials, and with the declining value of these commodities, these countries find it increasingly difficult to access the financing necessary to move towards industrialization and a knowledge economy.
- There are high levels of inequity within developing countries, many countries having developed a dual economy with a wealthy elite that has developed consumption patterns equal to those in developed countries, and the rest of the population living in abject poverty.
- The developing world is further characterised by a lack of infrastructure and basic services, and of the capacity and resources to improve and maintain existing infrastructure, let alone cope with the demands of rapid urbanisation.
- While the developing world consumes far less resources, and releases far less greenhouse gasses than the developed world, the environmental degradation experienced has a more direct and visible impact and present a more immediate threat to the physical survival of the poor living in these countries.
- Developing countries still have strong traditions of cooperative society and have developed sophisticated methods of conflict resolution and reaching common agreement.
- There is strong grassroots ability for innovation in the use of building materials, settlement development and institutional structuring that can be regarded as one of the most important resources in developing countries.

4. KEY ISSUES IDENTIFIED

4.1 Urbanisation and rural development

There are several interlinked issues under this heading. The first is that not enough attention is being paid to the linkages between urban development and investment strategies, and the impact this has on rural areas, as well as the possible synergies that can be developed through, for instance, transportation links and tourism. The second is that we need to reassess our ways of assigning value and ownership to land to enable densification of cities and reflect the true value of agricultural land. The third issue concerns the practicalities of making sure that new buildings and other construction projects in the formal sector creates sustainable built environments, and that existing buildings and other urban elements are used in ways that contribute to sustainability. There is an overall request that we need to rethink city patterns to support the new model of development and suggestions are made that models for new patterns can be found in the traditions of the developing world and its use of villages as the basic building blocks of human settlement.

4.2 Sustainability in housing

The integrated concept of housing as part of the urban fabric is not often contemplated by the construction industry or governments, yet it is one of the most pressing problems of the developing world. The housing problem concerns both formal and informal housing provision, as well as the policies that regulate housing provision. The informal sector is the biggest producer of housing stock in most developing countries and it is imperative that ways be found of harnessing the sustainability benefits offered by this sector.

It is rarely recognised that the shack, and informal settlements, represents a level of sustainable construction that many formal buildings and housing development projects will never be able to achieve. And while it does present some of the problems of inadequate shelter such as overcrowding, bad indoor air quality, inadequate services and insecure land

tenure; the formal low cost housing developments do not necessarily improve on these problems.

Several problems around rural housing were also identified. These centre on the effects of Western-style development models and attitudes to traditional materials and construction technologies, as well as the unavailability of financial and professional support for rural housing.

Housing policies that focus on quantity, instead of quality, and that ignore the most basic sustainability guidelines, as well as the fact that many developing countries have no housing policy to speak of, are further issues that need to be addressed.

4.3 Education

Ignorance and a lack of information on sustainable construction issues and solutions is a major obstacle that needs to be overcome. To bridge this gap will require interventions at all three levels of education, continued education programmes for professionals and technicians, education and awareness raising programmes for government officials and politicians, and a concerted public education programme. It is also necessary to create better mechanisms to allow transference of knowledge from research institutions to the market.

4.4 Innovation in building materials and methods

Sustainable construction can make a huge difference to global environmental sustainability, particularly through a drastic reduction in the use of natural resource consumption and energy intensive materials like cement, steel, aggregates and aluminium. Availability of conventional construction materials will fall considerably short of their demand despite improved productivity, and it is necessary to develop alternatives for them. One area that is receiving much interest is the use of agricultural waste products and other biological materials as building products. The other is innovative re-use and recycling. It is also necessary to support local economic development studies on how to marry traditional materials and construction methods with modern processes and technology in micro-production facilities. Above all the development of new materials and technologies need to take into account that the majority of the population is poor with very limited investment capacity and that technologies and materials that represent increased costs will not easily be adopted.

4.5 Modernising the traditional

Traditional communities have practical experience of the fact that humans are dependent on the earth's life support system, and have developed construction practices that make use of the natural materials from their immediate environment, re-using what they can and leaving demolition waste to biodegrade. Whether these practices are still viable in the current urban context is uncertain, but it is necessary to learn the lessons offered by these technologies and adapt them to modern times. However, these traditions not only provide us with examples of more sustainable construction patterns, but also with examples of processes for social sustainability and cosmological models that encourage more sustainable settlement patterns that can be used to inform modern solutions. It is suggested that the built environments created for cultural tourism are providing good examples of how the traditional can be modernised.

4.6 Gender equity

In many of the developing countries, women are still considered second-class citizens. It is important that the role of women as legitimate owners, users and producers of the built

environment is recognised. Among informal sector workers, women doing construction work are some of the worst victims of discrimination and special efforts need to be made to improve their skills levels and earning capacity, as well as to make the construction site more female-friendly.

4.7 Financing and procurement

There is a need to develop financing and procurement systems and regulations that will provide a level playing field for small, local contractors in tendering for government projects; that enable and encourage ecologically responsible building practices; and that assist poor home builders and those in the informal sector to access financing for housing and house improvements.

4.8 Governance and management

It is necessary to radically improve the capacity of government at all levels to play an active role in sustainable construction. This would mean improving the understanding of strategic decision-makers, training local government officials and finding financial resources to support them; and developing government procurement policies and legislation that encourage sustainable construction. The capacity of the construction industry itself to deal with sustainable construction also needs to be improved.

4.9 Needing a new model of development

The developing nations are today following the developed nations' policy of achieving economic growth through macro-industrial production, which revolves around the concept of large-scale production and high-consumption patterns. The consequent environmental impact is often overlooked. The question asked is whether the developing countries should continue pursuing this development model.

We are beginning to realise the price we have to pay for the kind of development the world has pursued for the past few centuries. The environment is rapidly deteriorating, social structures have been destroyed and the gap between rich and poor is bigger than ever before. In response, the developing countries are beginning to ask if Western-style development is the best route to take and if catching up with the West really represent development. One thought that came out clearly is that economic growth by itself is not development, nor are higher standards of living as measured by the ability to consume. What is needed is a new development paradigm based on moderate demands on the earth's resources and their more equitable redistribution. This would mean moving to a simpler lifestyle, evolving development strategies and processes that express local conditions, aspirations and control over resources, according women and other marginalised members of society their rightful place, and considering religious and spiritual ethics and values when formulating the new paradigm.

It is necessary to reflect on the cultural alienation and social de-rooting caused by industrialisation and urbanisation. It distances people from their own religious beliefs, spiritual values, cultural heritage, social norms, community behaviour and codes of personal conduct – in other words that which enables people to maintain a harmonious relationship with nature and society. Reinventing the relationship between people, and people and their environment, and rediscovering the values that defined it, is crucial.

5. BARRIERS, CHALLENGES AND OPPORTUNITIES

Lack of capacity in both the construction sector and in government, an uncertain economic environment; lack of accurate data on which to base decisions; poverty and the subsequent low urban investment and ability to pay for services; the lack of interest by stakeholders in the issue of sustainability; and technological inertia and dependency due to entrenched colonial codes and standards, were identified as the main barriers to the realisation of sustainable construction in developing countries.

Sustainability as a concept has only recently been introduced to developing countries and is not yet a priority. The major challenge for sustainable construction would be to get sustainability on the agendas of the industry, educational institutions, financial institutions, national governments, local authorities, and the public/consumer. Once this has been achieved, the challenges of reducing resource use, mobilising financial and human resources, improving environmental health and safety and developing new procurement approaches can be tackled.

6.CONCLUSIONS

While the process of formulating the *Agenda 21 for Sustainable Construction in Developing Countries* has not been completed at the time of writing this paper, some key issues and responses have emerged that are common to developing countries.

As a percentage of total environmental impact, the impact of the construction industry is probably more important in developing countries than it is in developed countries. However, biophysical considerations in the built environment have not been clearly articulated beyond the impact on environmental health and the industry does not pay adequate attention to its broader environmental impact. Lack of appropriate legislation/incentives and capacity for implementation has led to a construction industry with very little regard for environmental considerations. There is also no clear understanding yet of the tremendous innovation in building materials, service systems and construction processes that will be required – that to save the planet we will have to completely reinvent our built environments. This is one of the key issues that need to be addressed by both developed and developing countries.

Further, despite the sizeable environmental impact experienced, it is clear that the socio-economic components of sustainable construction are viewed to be the most challenging. Provision of affordable housing and related services has been clearly articulated in most government development strategies and policy, as has job creation, entrepreneurship, capacity building and gender equality, even if these are not always implemented. There is no doubt that most of the resources available to different stakeholders will continue to be directed to this challenge.

In a way, the required shift to a new development model would be easiest for the developing countries. Not only do they still have a living memory of life in another paradigm with other values, they are, by nature of the survival challenges experienced, used to innovation, adaptation and doing more with less. It may be that the developing countries are holding one part of the key to sustainability. However, we have to remember that both developed and developing countries hold knowledge and values that can contribute to a new vision for development, as well as the practical know-how needed to make it work. Establishing this dialogue on an equal footing is one of the first actions that have to be taken. In that light, it is intended that the Agenda not just concern developing countries, but also hold up some alternatives for the developed countries in their quest for sustainability.

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B. Arch from Jadavpur University, India, in the year 1988 with I class (72.4%)

M.E. in **Building Science and Technology** from University of Roorkee, India, in the year of 1990 with I class (69.7%)
Certificate course on **International Construction Management** from Lund University, Lund, **Sweden**, 1996.
Completed **Ph.D. Thesis** on **Design Parameters for Human Settlements in a Megacity – Calcutta Case Study** in Jadavpur University, India (degree to be awarded in December 2001 Convocation).

Professional Experience

Architectural work at different positions from 1990-1991,1995-96 and 1996 till date.
Independent Human Settlement Consultant for an integrated rural and urban area development programme to NGOs and CBOs.

Teaching Experience

As a Senior Research Fellow of Jadavpur University (J.U) took classes for undergraduate students of **Architecture** and **Construction Technology** department, J.U. During 1991-1995.
Visiting Lecturer of Architecture Deptt, Jadavpur University, 1997.
Lecturer in Smt. J.D. Birla Instt. Of Home Science, Cal-20, in 1997-1999.

Specialisation

Computer Application in Architecture : Programming languages – Fortran, C, Data structuring; MS Windows Office 2000 (Word, Powerpoint, Excel), AutoCAD, Adobe Photoshop.
Structural Analysis, Building Services, Construction –Materials & Technology.
Environment and Sustainable Development of Housing, Social issues in Housing.

Participation in Training Courses/ Conferences / Meetings/ Workshops

In 1991, participated in the training programme on New Mud Block construction and related technologies i.e. on Stabilised Mud Block, Brick Vault, Reinforced Brick Roofing and Filler Slabs, organised by Centre for Application of Science and Technology, Indian Institute of Science, **Bangalore** – 560 012, India.
In 1994 - 98, took part in organisation of series of International Workshops, organised by Centre for Built-Environment, **Calcutta** ; on topics - Housing Development and management, Architectural and Urban Conservation, Solar Architecture & Planning, Architecture : Future in Cities, Urban Agriculture and Sustainable Environment
In 1996, participated and successfully completed the Advanced International Training Programme on – International Construction Management at Lund University, **Sweden** and presented a country report.
In 1998, attended the Asian Coalition for Housing Rights (ACHR) meet on 'Building a regional direction and working process together' in **Bangkok**, April 16-20, 1998.
In 1998, attended the meeting of India Habitat Forum (INHAF) in **Banglaore**, and was selected as one of the founder members of the governing council of INHAF.
In 1999 attended a workshop and seminar on 'Balancing the load', Organised by IFRTD at Colombo, **Sri Lanka**.
In 2000, presented paper in New Millennium Housing Congress Singapore by Housing Development Board, **Singapore**.
In 2001, attended GEF awareness programme convened at Indian Institute of Joka,Calcutta.

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International

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9. ***Habitat, Environment and Community in Cities*** : International Housing Conference 2000 (IHC 2000) organised by Housing Development Board, Singapore, May 2000.
10. ***Strategic Leadership in Community Property Management*** : CIB W70 Brisbane Symposium 2000, organised by Queensland University of Technology, Brisbane, Australia.
11. ***Other side of the sustainable development*** .: The XXIX IAHS World Congress on Housing, organized by International Association for Housing Sciences, Ljubljana, Slovenia, May 2001.

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EC draft directive on energy performance: impact for the European building sector

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1. INTRODUCTION

The increasing interest in energy savings in the built environment, caused to a large extent by CO_2 emission reduction targets launched by the Kyoto protocol, has heigtened the need for tightening of energy policies and energy regulations in this sector. As the European Comission also finds this subject of very high importance, it has recently suggested harmonisation of energy regulations. In April 2001 the European Commission has presented it's draft directive COM(2001)226 on the subject of energy performance of buildings (European Commission, 2001). One of the main purposes of this draft directive is to develop a common methodology for energy regulations for buildings within Europe, based on the concept of calculating the energy consumption of buildings and setting energy performance standards. This methodology is widely known as the "energy performance method". Some EU-member states already make use of such energy performance regulations, others however use prescription of insulation values, heat loss calculations or heat demand calculations.

In recent years a small number of studies have explored energy regulations for buildings in European countries. A MURE Database Case Study has elaborated a comparison of thermal building regulations in the European Union with co-financing in the SAVE program (Eichhammer et al., 1998). A Joule study on this subject is the EPISODE project which has studied policy instruments for energy efficiency in residential space heating, building codes being part of this, for a number of EU countries (C. Schaefer et al., 2000). The SAVE project Energylink selected The Netherlands, Germany, Denmark and Italy for a study of their energy regulations (Bioarchitettura, 2001). A SAVE project that started March 2001 is the ENPER-TEBUC project, studying energy performance regulations and possibilities for a European model building code. Outside the scope of research in programs with European Commission co-funding some national studies in this field exist, for example in The Netherlands (Beerepoot, 2000).

The above mentioned examples of studies on energy regulations in European member states either cover a large number of member states but don't go into detail, either they cover only a limited number of member states. All studies were performed before the ideas of the European Commission in harmonising energy regulations were launched. In the study that was set up by the Dutch Ministry of Housing in 2000, four of the six member states were working on an up-date of their regulations. Therefore, even this recent study on energy regulations can not be considered to reflect the state of affairs at the time the ideas of the European Commission were launched.

The idea of harmonising energy regulations in Europe can have considerable impact for several member states, depending on the identity of their current energy regulations and depending on the identity of energy regulations as proposed by the European Commission. Existing studies on energy regulations do not reflect the current state of affairs on energy

regulations in European member states. Research studying the differences between current energy regulations and the scheme as is proposed by the EC draft directive does not yet exist. In order to be able to judge the effort needed for introducing harmonised energy regulations according to the EC draft directive COM(2001)226 and in order to see what can be learned from existing experiences, in this paper the comparison of energy regulations in eleven northern European member states is described.

2. RESEARCH METHOD

First, a framework was developed that would allow identification and categorisation of different types of energy regulations. The development of a categorisation model took place on the basis of existing literature in this field. Also the draft EC draft directive COM (2001)226 concerning harmonising energy regulations in Europe was explained and deduced to a ”table-format” in order to be able to identify the gap between existing regulations and the foreseen European regulations in the following chapters.

Next, energy regulations in eleven northern EU member states have been described on the basis of their existing regulations at the time of April 2002 or on the basis of regulations that will very recently be introduced. The inventory of energy regulations has taken place on the basis of collection of documents describing energy regulations in the different countries, like legal documents or manuals. In case of unusual languages, regulations have been interpreted with the help of translators. Energy regulations have been categorised according to the framework that was described in the beginning of the study. Differences and similarities with the foreseen developments of EC draft directive COM (2001)226 have been indicated on the basis of the simplified ”table-format”.

Finally, the overall comparison of energy regulations and efforts needed to meet the EC draft directive EC(2001)226 criteria has been covered in the last part of the study. From the overall comparison of regulations, it was possible to describe differences and similarities in current energy regulations among the member states, the efforts needed for harmonising energy regulations and a discussion on what can be learned from the analysis and comparison of energy regulations for future developments of harmonised energy regulations in Europe.

3. THE FRAMEWORK FOR CATEGORISING ENERGY REGULATIONS

In three existing studies on energy regulations, being the EPISODE project, the MURE project and the national study in The Netherlands by Beerepoot, regulations are classified in different categories, showing a degree of integration of the building as a system. In two of the existing literature sources, the EPISODE and the MURE study, the categorising of energy regulations is described according to the distinction into the following four groups (Eichhammer et al., 1998), (C. Schaefer et al., 2000):

1. Unit approach
2. Average transmission through the building shell
3. Maximum values for the heating demand of the building
4. Fully integrated approach

Another way of categorising energy regulations is the distinction into three types of energy calculation (Beerepoot, 2000):

1. Heat loss calculation
2. Heat demand calculation
3. Energy use calculation

The categorisation of Beerepoot (2000) covers the same subjects as the categories 2, 3 and 4 of the MURE and EPISODE categorisation. Category 1 of the MURE categorisation was left out, because only calculation methods had been considered for categorisation. This way of describing categories is based on the output of the calculation required for complying with building regulations. The combination of both the MURE categorisation and the categorisation expressed in Beerepoot (2000) seems to result in the most complete framework with most compact and clear descriptions for categorising energy regulations. This combination results in the framework, illustrated in figure 1. This framework is used for categorising energy regulations in the eleven northern European member states described in this study.

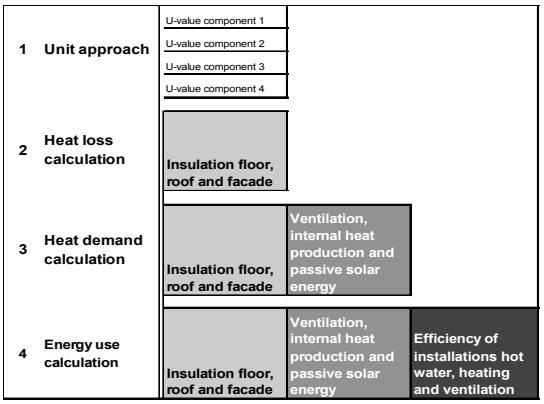

Figure 1 Framework for categorising energy regulations

In April 2001, the European Commission has published the draft directive COM(2001)226 on the energy performance of buildings in the residential and tertiary sector. The basic objective underlying the draft Directive is to promote the cost-effective improvement of the energy performance of buildings within the EU. The draft Directive makes use of the term "integrated energy performance standards". This is explained as being an approach that integrates, in addition to the quality of insulation of the building, heating installations, cooling installations, energy for ventilation, lighting installations, position and orientation of the building, heat recovery, active solar gains and other renewable energy sources. This explanation supports the statement that the "energy use calculation", the last category of the framework described in figure 1, can also be called the "energy performance calculation" or "energy performance method". The energy performance method is the method suggested by the EC for harmonising energy regulations. Member states making use of the last category of the framework described in figure 1 are therefore considered to already answer to a large extent the EC draft directive requirements.

4. THE COMPARISON OF ENERGY REGULATIONS IN 11 EU MEMBER STATES

Figure 2 presents an overview of categorisation of identities of energy regulations in 11 northern European member states, showing the state of affairs of energy regulations on April 2002 (Beerepoot, 2002). It shows that the "Unit approach", imposing maximum U-values to construction elements, is one of the ways of complying with building regulations in six member states, namely Denmark, England, Austria, Finland, Luxembourg and Ireland. In Austria, Finland and Luxembourg (only for buildings < 200 m^2) this is the main method for complying with energy regulations. In England and Ireland, although two other possible methods for complying exist, in practice the unit approach seems to be chosen mostly. In England, with a recent update of energy regulations in 2002, the unit approach is extended with standards for minimum efficiencies of hot water and heating installation systems. In

Denmark, where two other possible methods exist for complying, this method is used the least, because the other methods are considered to provide more design freedom.
This means that in five member states, Austria, Finland, Luxembourg, England and Ireland, the unit approach is either the only or the most applied method for complying with energy regulations. In England in this case extra requirements exist for boiler efficiencies.

From figure 2 it can be seen that the "Heat loss calculation", imposing a standard for the average insulation level of a building, is one of the possibilities for complying with energy regulations in seven member states, namely Belgium, Denmark, England, Finland, Sweden, Luxembourg and Ireland. In Germany, a requirement for the average insulation level of a building is one of the conditions for compliance with regulations. It is however not a possible method for compliance on it's own. In Belgium, Luxembourg (only for buildings > 200m^2) and Sweden, the heat loss method is the main method for complying with energy regulations. In Sweden, the requirement by means of a heat loss level is however accompanied by several additional requirements, as for hot water and heating installation systems. In Finland, the heat loss method is used if one can not show compliance with method 1, the unit approach method. The heat loss method allows trade-off between insulation levels of different construction elements, as long as the requirement for the average insulation level of the complete building is not exceeded. In England, the heat loss method is extended with minimum efficiencies of hot water en heating installation systems. In Denmark it is said that this method is not preferred because the third possible method for compliance offers most design freedom.
This means that in three countries the heat loss method is the main method used for compliance with energy regulations, namely in Belgium, Sweden (however several additional requirements exist) and Luxembourg (only for buildings > 200 $m^{2)}$.

Figure 2 makes clear that the "Heat demand calculation", is one of the possible methods for showing compliance in four member states, namely in Wallonia (Belgium), Denmark, Austria and Sweden. In Wallonia, it was stated that this method is hardly used, because it is considered to be too complex. In Sweden this method is indicated to be an extra option, to show compliance if this can not be shown with the most common method, the average U-value of a building (heat loss calculation). In Austria this method is being introduced as an alternative to the most commonly used method, the unit approach. Only in Denmark, this method is the most commonly used method for complying with energy regulations.

From figure 2 it can be seen that in five member states the "Energy use calculation" or "energy performance method" exists as a method for complying with energy regulations, namely Germany, France, The Netherlands, England and Ireland. In Germany and France, this method has been recently introduced as the only method for showing compliance: in France in 2001, in Germany in February 2002. In Germany, the requirement for energy use is accompanied by a requirement for transmission loss. Also in The Netherlands the energy use calculation is the only method for showing compliance with energy regulations. Here, the energy use calculation was introduced in 1996.
In England and Ireland, the energy use calculation is one of the three methods possible for showing compliance with regulations. In Finland and Flanders (Belgium), energy use calculations as a method for compliance with energy regulations are currently being developed. In Finland this method is expected to be introduced in 2003, as an extra possibility for showing compliance, if this was not possible with the other two possible methods provided. In Flanders, the idea is to introduce the energy use calculation as the only method possible for showing compliance in 2004.

	Unit approach	Heat loss calculation	Heat demand calculation	Energy use calculation
Belgium		Flanders (1993): "K-level" : dwellings only Wallonia (1996): Option 1: "K-level" : dwellings and non-domestic buildings Brussels (2000): "K-level" : dwellings and non-domestic buildings	Wallonia (1996): Option 2: heat demand calculation	(Flanders: Energy Perf. Reg. , expected 2004)
		(Wallonia (1996): Requirements for ventilation rates)		
Germany		EnEV (1 feb 2002), condition1: max. transmission losses	(Space Heating Demand + requirements for boilers: until 1 feb 2002)	EnEV (1 feb 2002), condition 2: max. yearly primary energy use
France		(Heat loss calculation GV: until 2001)	(Heat demand calculation BV: until 2001)	Option 1: Energy Performance Regulations + Thermal comfort in summer Tic. (Reglementation Thermique 2000) (2001)
		Option 2: Simplified procedure with "technical solutions"		
The Netherlands		(Until 1996)		Energy performance regulations (1996, current standard: 2000)
Denmark	Option 1: Max. U-values (BR '95/BR-S 98)	Option 2: Heat loss calc. (BR '95/BR-S 98)	Option 3: Energy frame / Heat demand calc. (BR '95/BR-S 98)	
United Kingdom	(Ap. Doc. L 2002) Option 1: Elemental method (+ min. SEDBUK efficiencies)	(Ap. Doc. L 2002) Option 2: Target U-value (+ possible correction factor for boiler efficiencies)		(Ap. Doc. L 2002) Option 3: Carbon Index Method: SAP calculations
Austria	All Bundesländer (1995): Maximum U-values for construction elements		Almost all Bundesländer (1995): Alternative to unit-approach: a heat demand calculation, comparing the situation with the unit-approach requirements	
Finland	(1985-1997) Method 1: Unit Approach	(1985-1997) Method 2: Average U-value of the building		(2003: Method 3: energy use calculation)
Sweden		(1994-1998) Average U-value of a building	(1994-1998) As an extra option, it is possible to show compliance by means of a trade-off calculations.	
	(1994-1998) Additionally, prescriptive requirements concerning limitation of heat losses, efficient use of heat and efficient use of electricity are covered.			
Luxembourg	Wärmeschutzverordnung 1996 buildings < 200 m2: Maximum U-values	Wärmeschutzverordnung 1996: buildings > 200 m2: k-level of a building		
Ireland	Option 1: Elemental heat loss method (TGD L 2002)	Option 2: Overall heat loss method (TGD L 2002)		Option 3: Heat Energy Rating (dwellings only) (TGD L 2002)

Figure 2 Energy regulations in 11 northern European member states

5. CONCLUSIONS

The analysis of energy regulations in 11 northern European member states in figure 2 showed that energy regulations in Belgium, Luxembourg and Austria are mainly based on transmission losses only. This covers only one element, thermal insulation, of the six elements required for determining the energy performance of a building according to the EC draft directive COM(2001)226 . However, Austria also gradually is introducing the heating demand calculation as an extra option, that covers more elements of the EC scheme. In Belgium, Flanders is developing energy regulations based on the energy use calculation. Those regulations are expected to be introduced in 2004.

The heating demand calculation method covers three elements of the EC draft directive; thermal insulation, ventilation losses and position and orientation of buildings. This method is used in Denmark as the main option for complying with regulations. The main difference between the heat demand method and the energy performance method as suggested in the EC draft directive consists of the consideration of heating and hot water installations in

regulations. For Denmark this means that implementation of the EC scheme requires including the impact of boiler efficiencies in energy regulations. Other elements requested be the draft directive that are not included in the heating demand method are consideration of lighting and cooling installations.

Sweden and France offer options that are based to a large extent on separate prescriptions for each the energy features of a building, although in France this is a simplified method for single family housing only. Although covering many of the elements as mentioned in the EC draft directive, it is not obvious that such a method is in accordance with the draft directive, since it speaks of "the energy performance" of a building, referring to one output of such energy performance. A method based on prescriptions of separate elements and not allowing an overview of the performance of a building in one clear indication that can be communicated clearly to inhabitants could therefore considered to be not in accordance with the purpose of the directive.

The energy use calculation includes at least four elements of the six as mentioned in the draft directive; thermal insulation, ventilation losses, position and orientation of buildings and heating installation and hot water supply. In some cases the elements lighting and cooling are included. In Germany, England and Ireland, a basic energy use calculation exists that does not include lighting and cooling. In France, the energy use calculation includes lighting. Here, cooling is dealt with by means of prescriptions, while inclusion in the energy use calculation is currently being developed and expected to be ready in 2003. In The Netherlands, the most extensive type of energy use calculation exists. Here, next to the six elements mentioned by the EC draft directive, also humidification, mainly in non-domestic buildings, is integrated in calculations. Even more remarkable is the inclusion of photovoltaic systems in the Dutch energy performance calculation. Electricity produced by photovoltaic panels, is rewarded by means of extraction of this production of the electricity use for lighting, fans and auxiliary energy for boilers.

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German Guideline for Sustainable Building

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1. PRELIMINARY REMARK

In order to promote sustainable building policies the German Government wants to set an example of sustainable building regarding to all new federal buildings.

Germany is a federal state. Although there are several regulations both at federal and at state level concerning environmental protection, a working aid for the integrated approach in design, construction, maintenance, operation and use of federal landholdings and buildings was missing. Thus, specific requirements according to the three pillars of sustainability have been elaborated. These are to be found in the annex to the guidline. We hope that the ecological and economical merits will convince other privat developers to follow us.

2. INTRODUCTION

This guideline is intended to implement integrated principles for the sustainable planning, construction, operation, maintenance and use of buildings and landholdings.

Sustainable building strives to minimise the consumption of energy and resources for all phases of the life-cycle of buildings - from their planning and construction through their use, renovation and to their eventual demolition. It also aims to minimise any possible damage to the natural environment.

This can be achieved by applying the following principles during the entire building process:

- Lowering the energy demand and the consumption of operating materials
- Utilization of reuseable or recyclable building products and materials
- Extension of the lifetime of products and buildings
- Risk-free return of materials to the natural cycle
- Comprehensive protection of natural areas and use of all possibilities for space-saving construction

The early implementation of sustainable planning measures can considerably improve the overall economic efficiency of buildings (costs of construction, operation, use, environment, health as well as non-monetary values).

When assessing economic efficiency, not only must the overall economic efficiency of the project be guaranteed, but the economic efficiency of every individual planning step must also be assessed in accordance with § 7 BHO.

In order to do so, the design team should consist of experts from the various disciplines under the leadership of the planner responsible for the overall co-ordination, and they should work closely together towards the aims of sustainability. Users and operators of the building must also be involved in the design phase.

Quality assurance includes measuring, documenting and monitoring the results of the construction and the use of the building, and reconciling these results with the design requirements (monitoring).

The opportunities for modifying the costs of a project are greatest at the beginning of the project. To a large extent, the cost-effective decisions will have been made during the definition of the programme and the initial concept phase. The same is also true for the impacts to the environment. Questions such as site development as well as planning law, function, urban planning, architecture and building regulations (especially stabilityand fire safety) must be fully assessed and optimised in terms of sustainability during the preliminary design and architecture and engineering competition stages.

Sustainable planning requires that equal consideration is given to the socio-cultural effects of the building project. Besides integration into the urban and natural environments, consideration must also be given to those aspects that affect people, such as the design of the building and the preservation of historic buildings and monuments.

Usually, buildings are used for long periods of time (on average 50 - 100 years). The temporal criteria, which are to be applied in the framework of the ecological and economical assessments, should be designed accordingly.

Sustainable building cannot be achieved by following a rigid concept. Instead, a specific concept or partial concepts must be developed for each individual project, and these concepts should include different approaches, alternatives and measures for the project.

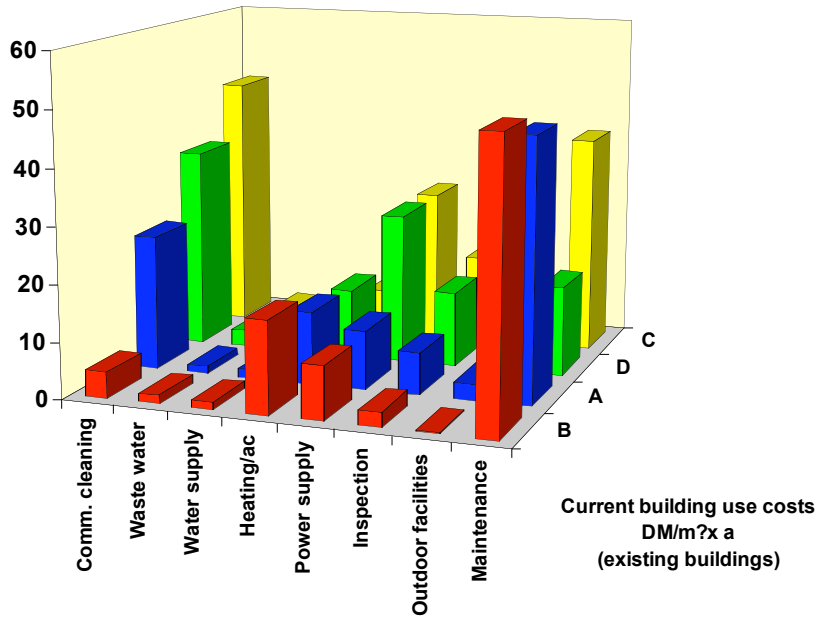
3. THE DESIGN

When designing buildings and their technical installations, care must be taken to ensure that

- the demands on functionality and design are fulfilled,
- health and comfort are guaranteed during the period of their use,
- costs for energy, operation and maintenance are minimised,
- the building can be operated with only low cleaning costs, or is partially self-cleaning (e.g. roofs and facades),
- the costs for inspection, maintenance and operation are kept at a low level and
- these items can be economically performed whilst also conserving resources and the environment as well as
- generating as little user-dependent traffic flow as possible.

Environmental impact is directly related to operational costs. The following items involve significant expenditures, as the case-by-case examples from 1998 demonstrate:

- Electricity/Cooling (15 - 40 €/m2 HNF·year)
- Cleaning (15 - 35 €/m2 HNF·year)
- Inspection and Maintenance (5 - 35 €/m2 HNF·year)
- Value-conserving Building Maintenance (5 - 15 €/m2 HNF·year)
- Heating (5 - 15 €/m2 HNF·year)



A primary requirement of the architecture and integrated building design is to minimise and optimise the technical installations through the correct choice of geometries and construction products. This can also substantially reduce construction and follow-up costs, and thereby environmental damages. The architect and design experts must therefore work closely together in the design team from the earliest possible moment.

By the interdisciplinary co-operation of all participants, a sustainability concept should be developed early on in the project. In this way solutions can be reached which are convincing as much through their functionality as through their positive affect on health, comfort, architecture, urban planning, form, economic efficiency, construction and ecological quality.

4. SPECIFIC REQUIREMENTS

The design principles described above lead to specific requirements on individual sectors and building trades. For the sake of clarity, they have been compiled in the following appendices.

Appendix 1: Checklist
Appendix 2: Planning principles for the design of buildings and landholdings
Appendix 3: Health protection and comfort
Appendix 4: Energy and building services
Appendix 5: Design principles for outdoor facilities
Appendix 6: Assessment of the sustainability of buildings and landholdings
Appendix 7: Building certification

Appendix 1 is a brief synopsis of the main requirements in the other appendices. It serves as a checklist for the specific requirements for individual buildings. It provides a handy tool which describes the tasks and checks involved in each step in the planning and decision-making processes. This checklist (Appendix 1) should be provided to the designers or competition participants for the preliminary design or competition phases. It highlights those requirements which have to be fulfilled in the preliminary or competitive design by means of drawing, written documentation or calculation.

Limiting, guideline and target values are stipulated for usage and operational costs. These cover in particular:
- Construction costs
- Electricity requirement
- Energy requirements for heating/cooling
- Inspection and maintenance costs
- Costs of value-conserving building maintenance
- Cleaning costs
- Water/sewage consumption and costs

All costs are relating to m² HNF and year.
The same applies to later design measures.

Appendix 2 describes the design requirements in terms of sustainability, beginning with the first planning phase. This appendix analyses in particular the impact of the construction, operational and maintenance phases on the architect's design. Specific requirements for specialist sectors, which are to be fulfilled by the individual design experts, are not discussed here. These issues are the subject of Appendices 4 and 5.

Appendix 3 gives the importance of the requirements for health and comfort, these have priority over the requirements for the building installations and
services. They also apply to all of the following requirements relating to specialist disciplines.

Appendix 4 includes all the main relevant design criteria for the design expert responsible for the building installations and services. However, the energy-related requirements can generally best be met by adopting an integral design approach.

Appendix 5 discusses the design of outdoor facilities within an integral overall design.

Appendix 6: the ecological and economical assessment of a building covers its entire life-cycle up to demolition. The ecological part is not initially made on a monetary basis. Social and cultural aspects complete the assessment of sustainability.

Appendix 7 represents a „building passport“. The building certification includes important key data on the building. It is of particular relevance to the utilisation phase (facility management) and for documenting the building's history (important for conversion or demolition works).

5. ECOLOGICAL ASSESSMENT

The ecological assessment of buildings during their long life-cycle is a part of the assessment of their sustainability. This also includes an economic and a socio-cultural assessment. Three protection objectives stand at the forefront of the ecological assessment:

- Protection of human health
- Protection of the ecological system
- Protection of resources

All ecological impacts are based on the flows of energy and material. The assessments are therefore based on the estimation or calculation of the extent of these flows. If precise data on the energy and material flows are lacking, then an attempt can be made to limit their relative extent by suitable measures at the source (avoidance strategies). Each assessment is based on system limits, and these must be known. Without this information the assessment is useless.

A basic distinction has to be made between qualitative (descriptive) and quantitative (calculative) methods for the ecological assessment of buildings and landholdings.

Qualitative assessments are easier to conduct than quantitative procedures. The results however often cannot be compared with another or are not
accurate enough, due either to different system limitations or to different reference values.

Quantitative assessments on the other hand are associated with considerably higher costs, due especially to the amount of data needed. This makes the implementation of computer-based tools both necessary and sensible.

In early planning phases (competitions etc.) the required input data are not yet available, so that a qualitative process is stipulated for preliminary assessments. As the planning process becomes more and more
concrete, this can be converted into a quantitative assessment (see Appendix 6).

6. ECONOMIC EFFICIENCY

Constructing and using a building both have an effect on the environment. High building utilisation costs are not only closely associated with a high level of environmental impact, but usually with high construction costs as well. Therefore considerable care must be given to reducing construction and operational costs when observing the above principles. Thus, besides the generally well-known design requirements for economic construction, three areas require increased attention:

- Analysis of the demand in terms of the type and scope of requirements
- Consideration of economic building construction procedures as early as the design stage
- Reduction of operational and utilisation costs, if necessary accepting an increase in construction costs for individual components, as long as § 7 BHO is complied with.

7. HEALTH, COMFORT AND SOCIO-CULTURAL ASPECTS

Buildings in which people spend their time must correspond to the needs of their users and should guarantee a high level of well-being.

The internal and external impact of a federal building reflects the democratic culture. Both, the relationship with citizens and the creation of historical values can be expressed by the impact of the building and this aspect must therefore be considered in the assessment.

Health risks resulting from the use of hazardous materials must be reliably excluded. The agreed objective is to create the best possible conditions for people residing and working in the interior areas of the building that are also acceptable from an economic point of view.

Factors that have particular influence on people's well-being and productivity include:

- Building architecture
- Geometry of the building and rooms
- Good design, materials, colour scheme
- Perceived room temperature
- Humidity in the room
- Air quality in the room (contents of the air in the room/hazardous substances)
- External air ventilation/air circulation
- Natural and artificial lighting
- Building acoustics/noise emissions

- Technical installations and furnishing.

The physical design parameters, which are defined by the planning of these items, must be determined on the basis of the existing technical specifications (DIN, VDI-regulations, AMEV-guides etc.), whilst taking the requirements of each particular case into account.

Demands on the health quality tolerance of building products are listed in the building regulations of the federal states of Germany through the Building Products Act.

The European Regulation on Building Products, its implementation at a national level and the international and European standardisation and registration of building products, have all led to building products being treated systematically and as a whole with regard to eight requirements. These are:
- Durability
- Suitability for use
- Mechanical stability
- Fire prevention
- Hygiene, health, environmental protection
- Safety of use
- Sound protection
- Energy conservation, heat conservation

Recognised health risks must be considered in the building product specifications.

Social sustainability covers a multitude of dimensions. The preservation of human health and well-being is an essential component. Many illnesses and restrictions on the quality of life are caused by or aggravated by environmental factors. In terms of the building sector, this affects both the people who live in the buildings and those who construct them. The requirements on health and well-being can be found in Appendix 3.

Due to their mostly prominent position and function, public buildings are increasingly a focus of public attention. They are endowed with a model function, which also has a creative component. Forming an important part of our building culture, they reflect how our society sees itself. They are a stable factor with a special responsibility with respect to the relationship between state and citizen. At the same time, if they fulfil their model role, then they are regarded with a special esteem and as a lasting value. Therefore the interests related to preservation of the building, its upkeep and maintenance as a witness of contemporary history, and cautious conformity to its surroundings are all factors of sustainable building that also have to be included in the design together with the general economic and ecological aspects.

Recycling[1] building materials by taking buildings apart instead of demolition.

Ad Roovers, City Development Corporation (OBR) Rotterdam

Every year we have in the Netherlands an amount of 16 millions tons of waste out of the building processes of new houses and demolition of old buildings. 10 Millions tons comes out of the demolition of infrastructure works and dwellings. That amount of waste is enough to build a new highway of more than 250 kilometres, that's more than from Rotterdam till Groningen

In the Netherlands legally waste don't exists anymore. Restproducts or remainings are to be used again in other processes. In fact we succeed in re-using the greatest part of all that waste but not on the level we would like. Concrete and stone is broken to what we call "repack" and used under new highways. Wood is used as fuel for incinerationovens
We would like to use materials on the authentic quality level, bricks not as broken pieces of bricks and for example wood for ordinary timber works



In the years to come the amount of waste in Rotterdam will be greater
In Rotterdam we have nowadays beside the renewal of the old neighbourhoods from before worldwar 2 also a renewal of buildings from after that period of time. A great number of old neighbourhoods have been under reconstruction in the great renewalprocess during the 70ties and the 80ties. Much of the renewed residential buildings have become now at the real end of the technical period of life. Even so in a number of old neighbourhoods that where kept beside the process of renewal the houses do not fulfil the basic demands.

Mostly that's means demolition of the old buildings and infrastructure to make space for new urban developments.

[1] The word recycling furtheron in this paper not used. Its assoicates with re-use as raw material. This Rotterdam initiatives tries to prevent re-use on the low level as raw materials by re-using products and materials on the high level they are intend to or as near by that level as possible.

Rotterdam developed in the years after the war in a very short while a great amount of new residential areas in new suburbs. During the 50ties and the 60ties we have had an enormous period of economical growth and therefore the need for labour. To fulfil that needs we build near by those new industries large new neighbourhoods? A good example is Hoogvliet, a part of the municipality of Rotterdam, suburb with 36000 inhabitants just beside the great petrochemical industries at Botlek Rotterdam. Roughly 17000 dwelling where build mostly as apartments in appartmentbuildings. In those days we have taken a lot of space for the new developments. Even now that part of Rotterdam has the most square meter green per inhabitant.

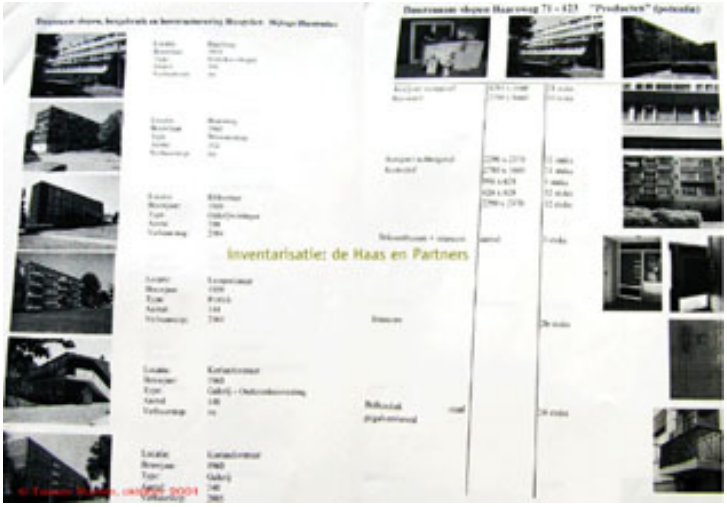
Never the less very great parts of this satellite city became in a socially bad climate, it pauperizes.

The cause of that was not only the quality of the dwellings. Technical they are 30 till 40 years old and mostly renewed during the 80ties. They do not fulfil the common demands of today. Technically they could certainly been used again. On the other hand we have had in Hoogvliet a great change of the population. The great industries do not need great amount of low skilled labour anymore. So new groups came instead of the authentic population.

In the eighties we had in Rotterdam a very high number of new inhabitants coming out of former colonies and as cheap labour out of the mediterainial areas. This groups where used to a lower standard of housing so they came in great amounts in the, by the authentic inhabitants left apartments. The renewal of Hoogvliet is not only a technical process or a simply new urban development.

What Hoogvliet needs is an economical and even more important social turnaround. The combination of all these reasons lead to a complete new plan for the major parts of this suburb.

Chosen is for the removal, by demolition of roughly 5000 dwellings in a period of 8 till 10 years. That process must lead to a new suburb with new inhabitants.
(The process of reconstruction was a major part of all municipality policies. All participants in the process, inhabitants as well, where properly informed and even take part in the decisionmaking process)



This is the palette of the project re-use as we put up in Rotterdam.

We have chosen in this project for re-use of materials if possible on the authentic quality level.

It is interesting to known that in the same time even in the same area an initiative is taken to recycle building materials as secondary raw material. In Rotterdam we will be following that project.

Maasoevers founded one of the initiatives. Maasoevers is a housing corporation In Hoogvliet. With a share of 4000 of the total amount of 5000 dwelling to be demolished Maasoevers is in the area a major party.

It that scale that makes things also economically worth while to think about other than the traditional solution. For this project it was also very important the Maasoevers has a high ambition concerning sustainability.

The corporation had in the past already had some experience with re-using of installation-parts. To keep up maintenance of the most common installed heating system they had after this system got out of the market a policy of collecting en save keeping old installations and parts.

In the process of reconstruction in Hoogvliet 4000 dwellings out of the stock of Maasoevers will be demolished, the last one of them at about 10 years from now. A great amount of dwellings must be kept, in at least a reasonable shape. The remaining exploitationperiod is to short to finance major investments. The corporation is therefore obliged to cut on costs and re-use as much products and materials as possible.



By introducing new policies on maintenance and re-using good “old” materials new opportunities appeared. In what we call mutation-maintenance to prevent the former tenant to use the old key to come into the house, a number of locs is replaced. Based on inspection also parts of the kitchen, the toiletpot and things like that are replaced.

More and more old and of course cleaned and checked products, are been used.

Based on a number of other aspects was also in the municipality an initiative regarding re-use founded.

Within that initiative the aspect of re-using materials is combined with creation of new employment and getting more control on the quality of live in neighbourhoods in witch large urban developments take place.

We found out that the common process of demolition is not suitable when you want to re-use the building materials. You need an other sort of process on a complete other scale. Instead of the traditional demolition you must chose tot put down a building by taking it bit by bit apart. The need for labour is much more

The traditional process requires a great amount of dwellings to afford the great machinery used to tear down buildings. To come to that amount takes time, sometimes several years. During this period however door and windows are kept closed with wood, bricks or metal al sort of not-wanted activities take place.

Besides major parts of streets blindfolded creates an unsafe atmosfere.

Now together with Maasoevers the Municipality of Rotterdam created a project on re-uses. Phase 1 of this project was an inventory on demolitionproject in the years to come. The second part was an investigation about the quantity and the quality of the products and materials that can come available. Phase 2 was early this year with the presentation of rapport completed. On a much lager scale and for the whole of the municipality a same sort of investigation takes place now.

Till now it became clear that in great amounts and often in good qualities al sort of product can come available. The next step is finding the places or projects tot re-uses the products or materials.

The use of other than new materials in the Netherlands is nowadays far from common. There is a small market for metals (copper, lead), construction-steel, tiles and wood.
In creating new opportunities for used buildingmaterials a number of difficulties are to be won.

In other countries already possibilities for re-using exists. Recently we have had the first big project in Hoogvliet where materials where taken out. Synthetic window-frames from excellent quality came available without a scratch and where sent to former war-area in Eastern Europe. Also other countries are interested.

For the Dutch market we have searched for special projects. Not only most it is possible to use a serious amount used buildingmaterials the project must also give this material e new and better image.



In a co-operation from several municipal services we have found just the right project. In Rotterdam as in many other cities the space between infrastructure works as railroads and highways is used for allotments with small summerhouses. People that live in the density of the city and don't have a garden of their own using these. Generally the users of these allotments already have more than average interest in environment.

We have made contacts with the union for gardeners and found out possibilities to work together in this project.

The allotments are located on all sort of places in and round the city. They can become small distributioncenters for used building and gardening materials. We think there are possibilities as well making new employmentprojects by making prefab parts for summerhouses and other small cottages.

Always important are the costs of a project.

Phase 2, the investigation has shown that at prices to sell re-used materials at 30 percent of the new costs the project of taking buildings apart bit by bit cost no more than traditional demolition. Profit for the society or the municipality is not included. Not included is the effect on employment by bringing unemployed people to work again.

We in Rotterdam start next spring with Ecotopia, an allotmentcenter for 70 gardens and summerhouses.

Pictures :Hergebruik/Volkstuinhuisjes

Different Aspects of Slum Improvement Problems

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1. INTRODUCTION

The main goal of "The Slum Upgrading at Deponija Gypsy Enclave" project is to improve living conditions for the people situated in a devastated surrounding, through instigation of environmental, social and economic programs. The inhabitants of the studied settlement are the Gypsies (Rroma), part of the ethnic minority which in most cases falls within the poor and socially vulnerable categories of population. Up to 80% of the Rroma population lives in poor enclaves, such as slums and unsanitary settlements, often with no basic infrastructure or utilities and in improvised homes[1].

Efforts in finding solution to the actual problem involved different stakeholders and at the same time raised many questions which are left unanswered and open (lack of social housing policies, inadequate legislation, lack of social housing standards and norms, lack of precise figures for socially disadvantaged and vulnerable groups). The search for solutions was conducted step by step, with gradual introduction of the stakeholders, all in purpose of finding the most flexible solutions to fit within the present legal framework.

The fact remains that the social housing issue in Serbia was given almost no significance in the last decade. In circumstances of drastic pauperization and deprivation, where over 50% of population is categorized as poor, this issue expands to a larger scale[2].

This specific project was one of the first to adopt the integrated approach to the solving of social problems. It allows interdisciplinary and sectarian cooperation, urgent problem solving and improvement of life conditions. In recent months this issue has been approached from different levels (regional social cohesion of the Southeast European countries, national housing policy[3], social housing policy, national strategy for permanent integration of the

[1] (K.Petovar, Belgrade Consultation on "Making Cities Inclusive", 2002)
[2] Presently in Yugoslavia there is a number of socially disadvantaged groups with flimsy prospects of providing themselves a decent housing. Within the risk groups are mainly: young persons, young families on low income, families with more children, refugees, internally displaced persons, Gypsies, single mothers, physically and mentally handicaped, old people and other socially vulnerable categories.
[3] In present terms of drastic impoverishment of citizens, the housing policy that will primarily and solely have a social component can't be efficient nore just. Housing policy and housing program support need to put emphasis on development. It includes endorsing regional development and weakening of the pressure of immigrants on the big cities where living costs are much higher, and support or even favoring of housing programs for young and educated, as bearers of development programs

refugees[4], harmonization of the regulations, strengthening of institutions, capacity building on national and local levels, attaining mechanisms and financial framework).Various international organizations are currently present in Yugoslavia offering their expert assistance in this field through donors.

This project represents one of the possible ways of consideration of social housing issues as well as an example of good project management.

2. THE "DEPONIJA" PROJECT

"Slum Upgrading Project at "Deponija" Gypsy Enclave: Legalisation, Education, Economy, Housing, Environment, Women Program, Local Community" has been initiated in October 2000, with financial assistance of the European Commission, NOVIB and UNICEF. The Project is being implemented by the Society for the Improvement of Local Rroma Communities (SILRC) together with partner organizations: Humanitarian Association "Roma Heart" and Rroma Women's Center "Bibija". The project also involved other institutions and companies as participants: The City Assembly, local municipality, City public and communal companies, schools and health institutions.

The main objective of this project is to help the Gypsies, dwellers of the illegal slum called Deponija (characteristic for it's depressing appearance and hopeless development prospects), create an enclave which would enable them to satisfy their basic needs in a modest and dignified way. The goal is to raise the quality of these people's lives, clarify their legal status, and help them integrate into the urban system and structure. It is all about making an effort in order to provide these people with certainty of achieving their basic human and civil rights.

2.1 The "Deponija" settlement and its problems

The Deponija is comprised of five or six settlements that emerged on the banks of the Danube River in 1970s on the site for one of Belgrade's garbage dumps. Today it is part of the industrial zone in which construction factories and gravel storage are located. The Rroma settlement grew simultaneously with the development of the industrial and public utility area on the land allotted to the Port Authority and the Customs Free Zone and expanded with the sudden arrival of Gypsy refugees from Kosovo in recent years. The living conditions can be described as in the worst of slums: no running water, no basic infrastructure, extremely unhygienic conditions, flimsy houses made of anything that came in handy. Families live in cramped hovels mixed with refuse, most of them without electricity.

The legal position of these people is not quite clear, their settlement is scheduled to be torn down but no one knows when this will happen. Deponija is one of the harshest slums and one of the worst of the 150 Rroma settlements located in Belgrade. The Project focuses on giving these people and their settlement adequate treatment.

2.2 Housing Area / Construction Activities

Given all the facts, the slum improvement model which incorporates it's legalization and complete sanation could not be successfully implemented at this point. The term *legalization*

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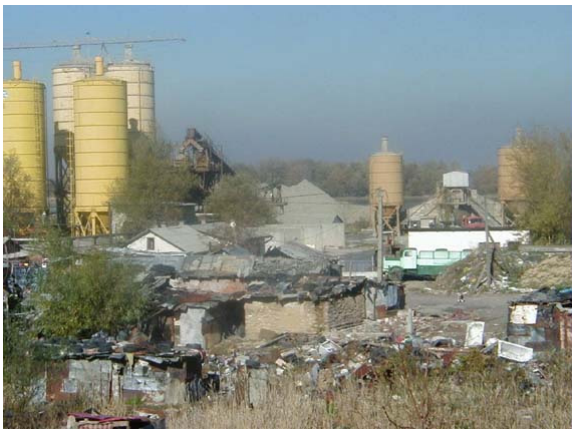
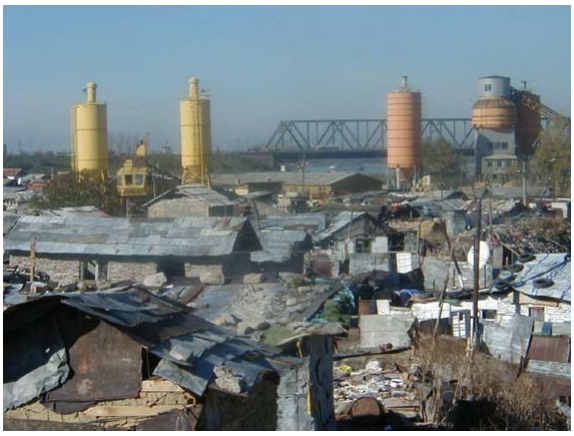
and quality changes in social, economic and cultural progress in countries in transition.(K.Petovar, Belgrade Consultation on "Making Cities Inclusive", 2002)

[4] According to the last census there is 700.000 exiled, war striken and displaced persons (around 10% of the domicile population of Serbia), who fled to Yugoslavia due to wars, exodus and discrimination. (National Strategy for resolving issues of exiled, expelled and displaced persons, The Government of the Republic of Serbia, UNCHR, Institute for Economy, 2002)

was used here as a framework for improvement of the legal status of the inhabitants and initiating the process of attaining the permanent status of the enclave.





Rroma settlement Deponija is a part of the Danube industrial zone. Settlement grew in between construction factories, and today some 170 families live in it.

Various social activities (registration of the dwellers, employment, education) are followed by a set of environmental programs: cleaning of the homesteads and common grounds, remodeling of the enclave, construction of a hygienic unit and communal multipurpose space.

The problem of building on someone else's land was overcomed by a special Protocol between the City and SILRC. It required houses to be made of light / detachable parts or units, on provisional foundations, so that it can all be eventually moved and relocated to a permanent location.

During the design and the building phases, two different methods have been used: one applied to family homes and another to houses intended for public / common use. Present homes don't meet the minimum standards and conditions for living, so their partial sanation is not technically possible. The project plans for construction of three houses for the families that need them most. Those are groundfloor, simply constructed houses, built of ecological and cheap material, with their function adapted to the Gypsy way of life. The area of 50 square meters should accommodate 6 to 7 family members, with possibilities of further "house developing" and phased construction. This would of course depend on a financial capacity of the users. Each house is equipped with basic utilities (water, sewage, electricity). The building of the houses would also represent a form of training for the enclave members, who will take part along with professional craftsmen.

As for the multipurpose building, it was approached from a completely different direction. It is intended for gathering of people (especially children) and different activities and community programs. Even though this is an extremely poor settlement, the idea was to build a future central building (nucleus) of the enclave, provided with the best possible features. In terms of architecture, construction and materials and equipment used, it meets high modern standards.

3. THE POSSIBILITIES OF LEGALIZATION

All analysis made within the Project (analysis of the Deponija environment, analysis of the existing urban planning documents, architectural assessment, analysis of the needs and intentions of other stakeholders interested in the Deponija location) point out that the

legalization of the settlement is hardly feasible. This called for the search of alternative solutions within the present legal framework.

Alternative ways of legalization:

I. Request to legalize a facility – the illegal construction is not in accordance with the planned use. There are little chances that a building permit will be issued upon such a request. No data are available as to whether the Commission (municipal) has made an inventory of facilities and noted whether conditions are fulfilled for a building permit or usage permit to be issued,
II. Request to issue a temporary permit – the arguments for approving a request to issue a building permit to house socially handicapped persons are: to temporarily provide hygienic conditions for housing, to improve the conditions under which the space is used; the manner and scope of work will not be an obstacle when the space is used for its planned purpose,
III. Request for housing for socially handicapped and displaced persons from Kosovo – since a number of families in Deponija (around 60) are displaced from Kosovo, it is possible to try the procedure of building apartments/houses (or some other form of individual or collective housing) on a new location(s) in order to provide them permanent housing,
IV. Request to build apartments/houses to accommodate socially handicapped individuals – solidarity housing or housing for socially handicapped individuals, if there is a Solidarity Fund with resources to provide for the construction of these apartments, establish priorities, etc.

Here we would propose the best procedure as being the one already initiated which is not to legalize[5] in the formal sense but to receive permits for the temporary use of the facilities, until the land is used for its planned purpose, and pursue the provisions of the Law on Planning and Developing Space and Settlements, the Building Law, and the Land Use Law. Work can also be undertaken on proposals III and IV parallel with this procedure.

4. CONCLUSIONS

Social housing issues are becoming one of the priorities of the overall social policy. The "Deponija" case study came to the following conclusions:

There is a need for:

- National Housing Policy and legal reform,
- Further institutional reform within the housing sector which strenghtens housing finance and subsidy regimes, so that affordable and adequate housing is available to all vulnerable groups,
- Developping strategies to make land available for development and growth,
- Strengthening urban planning and financing mechanisms to be more responsive, efficient and effective in order to realize social housing programs,
- Institutional reform (new types of social housing organizations which provide affordable housing, improving strategies for targeting service programs and housing for social groups),

[5] The concept of legalization is used in the sense of elaborating and obtaining proper documentation in order to receive a building permit for a temporary building

- Building a shared body of knowledge and training methodologies (refined technical tools, revision of existing norms, standards and recommendations in respect of specific social, environmental and financial needs and possibilities),
- Developping mechanisms and institutions for housing financing, including micro-finance, especially for poor and vulnerable groups,
- Giving priority to building of the low cost, standard, "developing" houses in accordance with the needs and aspirations of users,
- Developing means for incorporating users' initiative and direct work participation in building their own homes.

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Sustainable building assessment methods in South Africa: an agenda for research

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1. INTRODUCTION

A vast amount has been written about the concept of sustainable development. The widely accepted definition of sustainable development is "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED, 1987:43). According to *World Watch*, one-tenth of the global economy is dedicated to constructing, operating and equipping homes and offices. This activity accounts for roughly 40% of the materials flow entering the world economy, with much of the rest destined for roads, bridges and vehicles to connect the buildings (Roodman and Lenssen, 1994).

Since the early 1990s, building environmental assessment methods have been perceived as useful tools for promoting environmental awareness amongst built environment professionals. Cole *et al.* (2000) define building environmental assessment methods as tools for evaluating building performance with respect to a broad range of environmental considerations, organised into assessment criteria. These assessment methods vary in scope, structure, format and complexity.

The Green Building Challenge '98 (GBC '98) is an example of a recent, largely northern hemisphere, attempt to develop a universal method for measuring building performance across a range of environmental issues. Flowing from the GBC '98 was the international building environmental assessment method, namely, "The Green Building Tool (GBTool)" assessment framework. This framework is applicable to different types of buildings and focuses on environmental factors. Cooper (1999) contends that such current international attempts at developing a universal, standardised method for assessing the environmental performance of buildings are inherently flawed. He argues that such methods are found wanting in that they are culturally implicit, and that such methods or tools "*treat the sustainability [of the] wider built environment as simply a matter of energy and mass flows without due regard to the socio-economic and political dimensions of sustainability*" (Cooper, 1999: 329).

Such an approach ignores the other dimensions of sustainable development – economic, social, technical and process-orientated considerations. This shortcoming is particularly

significant in the South African context, where the explicit goal of the National Environmental Management Act (107 of 1998) is the attainment of sustainable development. This, and other contemporary legislation and policies of the South African government, explicitly incorporate the philosophy of sustainability. Other such examples of this goal are found in the Housing Act (Act No. 107 of 1997) and the National Housing Code (1999) which both clearly state that the delivery of housing should implement and uphold the principles of sustainable development.

Dominating development and the construction industry is the world imported from the West, with its order, its advanced technology, and its emphasis on economic growth and material wealth. In contrast there are the developing countries struggling with the dichotomies of air-conditioned skyscraper cities and manicured suburban lawns surrounded by vast tracts of low cost housing and informal settlements (du Plessis, 2001). du Plessis (1999) states that real sustainable development in the construction industry requires a completely new way of looking at the built environment. She asserts that the construction industry should not consider only its environmental impact, but also the social impact of its activities and how it can address the challenges of developing nations in a sustainable way. This assertion is supported by the framework for sustainable construction that incorporates principles for the biophysical, economic, social, technical and process-orientated dimensions of sustainability (Hill and Bowen, 1997a).

Developing countries often adopt strategies and methods of the developed world. There is cause for concern that South Africa may be tempted to overlook important areas of sustainability if theories and methods are adopted from developed countries without adaptation to suit local requirements. Sustainable development will not be achieved in the construction sector in South Africa, or on a global scale, if this sector adopts a fragmented approach to development that ignores crucial dimensions of sustainability, or a 'one-fits-all' approach whereby an international assessment method is applied to different buildings in different localities.

If construction happens in a sustainable manner, the positive impacts flowing out of this will be felt in the biophysical, economic, social and technical dimensions of life in South Africa. Given that these dimensions are interrelated and that they cover just about every aspect of life, South Africans would be better off as individuals and as a nation if this were to take place.

A comprehensive building assessment scheme therefore requires consideration of all the environmental, economic, social, technical, cultural and political impacts of a building development throughout the planning, design, construction, operation and deconstruction stages of the procurement process. The emphasis of assessment methods hitherto has been on the operations phase of the building life cycle (Hill and Bowen, 1997b).

The Council for Scientific and Industrial Research (CSIR) responded to the shortcomings of the GBTool through the development of their preliminary Sustainable Building Assessment Tool (SBAT). However, this tool operates as a problem-identification method, and does not provide for the detailed assessment of the full range of sustainability dimensions inherent in buildings (Kaatz *et al.*, 2002).

2. AN AGENDA FOR RESEARCH

Having identified the shortcomings associated with the utilization of sustainability assessment methods in the northern hemisphere for use in developed countries, a research project was initiated at the University of Cape Town in 2001 with the aim of developing a method for the sustainable assessment of buildings in South Africa. Funding was secured from the National Research Foundation (NRF) for a 5-year period.

The research project has the potential to have a positive impact on sustainable development, and sustainable construction, in South Africa. Construction activity is occurring at a rapid rate with houses, schools, industrial parks, office blocks and hospitals being built to meet the needs of the South African population. Alongside this is the goal of sustainable development which government states explicitly in its new policies and legislation. If this construction is not sustainable, the ability of future generations to meet their needs will be compromised.

The main goal of this project is to develop assessment methods which will be straightforward and user-friendly. Social and community development disciplines would benefit as they would assess the social sustainability of buildings during the design phase. Input from professionals in the social sciences would have a positive impact on the quality of life of the users and inhabitants of buildings. Likewise, specialists from the economic and environmental fields would have input into the planning of developments and design of buildings, using the assessment methods as checklists for sustainability criteria. In this way, factors which may be overlooked by engineers or builders can be taken into consideration early on in the construction phase.

The main research questions to be addressed in this project may be listed as:

- How applicable are the environmental considerations inherent in the GBTool/Sustainable Building Assessment Tool to building developments in South Africa?
- How contingent are environmental assessment methods on the type of building structure and its geographical location?
- How best can the social, economic, technical and process-orientated dimensions of sustainability be incorporated into an assessment of building performance?
- How contingent are multi-dimensional methods of sustainability assessment on factors such as the type of building structure, its geographical location, and cultural issues?
- How appropriate is an integrated sustainability assessment method to the evaluation of building performance?
- What purposes should such methods serve, and how are the results best utilised?

Flowing from the above, the objectives of the project are to:

- Examine the appropriateness of the GBTool on a variety of South African buildings, both in terms of its focus, approach, and in terms of the relevance of factors such as the type of building, geographical location and the cultural context of built environment groups.
- Define the dimensions of sustainability in the planning, design, procurement, construction, operation and deconstruction of buildings in South Africa i.e. establish a conceptual framework for sustainability in the built environment.
- Refine the environmental considerations inherent in the GBTool, and review and refine the Sustainable Building Assessment Tool developed by the CSIR, in the development of South African building environmental assessment methods, drawing on the South African procedure and approaches for Environmental Impact Assessment (EIA).

- As an extension of the environmental dimension above, explore and develop assessment methods for enhancing building performance with regard to the social, economic, technical and process-orientated dimensions of sustainability.
- Determine the pertinence of factors such as the type of building structure, its geographical location and cultural issues on methods for the assessment of the sustainability of buildings.
- Test the sustainability assessment methods on a variety of South African buildings.

The CSIR have agreed to collaborate with the NRF team in the review of their preliminary Tool, and the conceptualization and development of more specialized, dimension-specific assessment methods.

A valuable result of the research undertaken to date has been the establishment of new collaboration links with various international organisations and/or people, the first being the link created with Dr Ray Cole, one of the initiators of the Green Building Challenge. Research links have also been established with the School of the Built and Natural Environment at Glasgow Caledonian University, as well as with the Department of Building and Construction Economics at RMIT University, Australia. A joint RMIT/UCT project examining the sustainability of indigenous housing for Aboriginals in the Northern Territories has been initiated in parallel with the NRF project. ARUP have undertaken to make their case studies available to the research team and to provide critical comment on publications compiled by team members. The CSIR have invited project members to utilise SBAT for the assessment of buildings in 2002. In addition, they have undertaken to provide information relating to two case studies where SBAT was applied. The Department of Construction Management and Quantity Surveying at Peninsula Technikon in Cape Town is also participating in the project.

3. PROGRESS TO DATE (APRIL 2002)

The GBTool has been examined with respect to its appropriateness within the South African construction context. Advantages and disadvantages of evaluating South African buildings using the GBTool were documented in detail in the report "Environmental Sustainability Assessment Methods for Buildings in South Africa" prepared by the research team. The next phase of the project is to test the GBTool on actual buildings. For further information on this report, please refer to the paper presented by Kaatz *et al.* in this conference proceeding.

Definitions of sustainability dimensions within a construction development life-cycle were compiled in a paper entitled "The transition to sustainability in the planning, design, construction and management of the built environment in South Africa". The paper, prepared by the research team, discusses South African trends in the transition to sustainability for each of five stages in the life cycle of the built environment: urban planning, project design, manufacturing of building materials and products, construction, as well as maintenance and management. The paper has been accepted for publication in the International Journal of Environmental Technology and Management, in a special issue on "Sustainability in the Built Environment".

The Sustainable Building Assessment Tool (SBAT) developed by the CSIR was evaluated along with other building assessment methods (e.g. BREEAM, LEED, GBTool) with regard to their appropriateness to address the environmental sustainability of South African buildings. The report compiled by the project team ("Environmental Sustainability

Assessment Methods for Buildings in South Africa") was sent to the CSIR for critical comment.

In the above analysis it was noted that none of the examined building assessment methods comprised social, economic and technical criteria, except for SBAT, and then to only a limited extent. As the research in 2001 focused mainly on the biophysical dimension of sustainability, social, economic, technical and process-orientated dimensions were not analysed in detail. These dimensions of sustainability will receive greater attention in the near future.

4. FUTURE RESEARCH

4.1 Phase One

In order to examine and refine the appropriateness of the GBTool for South African buildings, a through examination, by means of case studies, of the appropriateness of the GBTool, the CSIR's Sustainable Building Assessment Tool, and related environmental assessment methods for the selected buildings will be conducted. Once the results have been obtained and analysed, the assessment methods will be refined for the development of South African building environmental assessment methods. Reports will be circulated amongst relevant professionals and feedback sessions, in the form of workshops, will be conducted.

4.2 Phase Two

Prior to defining a conceptual framework for sustainable building assessment methods in South Africa, it is essential that members elicit information from as wide a source as possible. To facilitate the propagation of this information, a website will be developed. The team has undertaken to participate in the CIB TG48 Task Group on Social and Economic Aspects of Sustainable Construction.

4.3 Phase Three

The various definitions of sustainability will be examined in an attempt to find common ground between the ideals of 'sustainability' in general, and those of 'sustainable construction' in particular. Hill and Bowen (1997b) state that four attributes of sustainability – biophysical, economic, social and technical – have been singled out to advance the understanding of the concept of sustainable construction. In order to critically examine the applicability of, and importance allocated to, each of the four 'pillars' of sustainability, the team will develop a framework for sustainable construction.

The thrust therefore will be to, *inter alia*, develop the assessment methods with regard to the economic, social, technical and process-orientated dimensions of sustainability, and determine the pertinence of type of building, geographical location and cultural issues on assessment methods. Various area-specific specialists, e.g. social anthropologists, public participation experts, community development specialists will be consulted. Their input will assist with devising factors and assessment criteria for each dimension of sustainability.

4.4 Phase Four

Thereafter, sustainability factors and means of measurement will be formulated into assessment methods. In order to examine the appropriateness of the devised assessment methods, case studies will be conducted. An analysis of the results will facilitate in further refinement of the assessment methods. The results will once again be circulated amongst relevant professionals and workshops held.

5. CONCLUSION

In order to be globally competitive with other markets, sectors of the South African economy need to keep up with international trends. It is foreseen that the research would enhance economic growth in South Africa by improving international competitiveness of the construction industry. If the South African construction industry was to adopt methods of sustainability, the industry would positively affect the quality of life of people, since sustainable construction aims to build quality human settlements and buildings that are healthy, habitable and affordable. The findings emanating from this research project would further contribute to improving the efficiency of resource utilization in buildings and reduce the impact of building activities on the biophysical environment. The authors would welcome any comments and ideas on the research questions and objectives outlined in this paper.

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Towards Sustainable Buildings in Turkey with Special Reference to Energy Efficiency and Aseismic Design

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INTRODUCTION

The building construction sector is one of the major constituents of Turkish economy, which shares 11.4% of the Gross National Products 2000. The measure is an important indicator of their economic success in increasing the per-capita income; however, it does not account for the environmental impact of their activities such as energy consumption, air pollution and the effect on long-term societal well-being. Their impact upon energy consumption and air pollution is in four separate ways; the production of building materials, the construction process, the operation of buildings in use, the infrastructure and transport costs of servicing buildings.

Anatolian crust is torn with various faults. Nearly 95% of the land is effected by fault zones, therefore the land is in very high seismic risk. Earthquakes with high to very high ground acceleration occurred in Turkey were often disastrous to buildings and sub-structures, that cause loss of life, land and sea pollution and effect on microeconomic structure of the regions and macro-economy of the country. Therefore, seismic architecture, construction of earthquake resistant building and retrofitting of existing buildings and sub-structures are the specific cases for the economy and sustainable development of Turkey.

Energy is a key factor in Turkey's economic development and Turkey's energy policy is important in its sustainable development. The objectives of Turkish energy policy are largely in line with those of the European Union. They are concerned with security and diversification of sources of supply, market principles, environmental standards and improving energy efficiency, (ECC, 2001). Turkey's energy policy on energy supply and protecting environment are to ensure a supply of energy to all consumers at affordable prices and promoting healthy competition on the energy market while respecting the environment. Also, an energy policy developed to influence the energy consumption, however the government and local authorities are not keen to apply the related regulations. Therefore, improving the efficient use of energy and energy conservation remain a key issue of the energy policy.

The operation of buildings in use consumes 34.5% of the total energy of the nation and is responsible for a similar proportion of the carbon-dioxide emission. Therefore, energy used in the operation of the residential buildings is central to sustainable building strategy of Turkey in order to conserve fossil-fuel supplies and reduce carbon-dioxide emission. Most of the energy consumed goes on space heating, followed by water heating, cooking and lighting. As space heating is the largest component, much attention is focused on in terms of applying or

increasing levels of thermal insulation. In Turkey, the measures to promote energy efficiency in buildings is the responsibility of the Ministry of Energy and Natural Resources through Energy Conservation Co-ordination Board and National Energy Conservation Center. They have implemented new norms for thermal insulation standards for new buildings in order to improve energy efficiency in buildings. Another aspect of the improvement of energy efficiency in buildings is that major renovations of the existing buildings had to be performed in order to comply with the new thermal insulation standards.

ENERGY EFFICIENCY IN BUILDINGS

There are 7 838 675 buildings of all use in Turkey (2000). Residential buildings present 74.9% of the existing building stock. One of the important statistics is the age of the buildings. 77.3% of the existing building stock was constructed before 1970 and only 22.7% was constructed afterwards. The above separation is important as the reference year 1970 is the date when the "TS 825 Turkish Standard for Thermal Insulation In Buildings" has been activated in the building sector. In other words, 77.3% of the existing residential buildings were thermally uninsulated. The remaining existing buildings were thermally insulated; however, they were unable to exceed the values determined in the international standards and specifications for energy conservation. Therefore, the operation of the existing residential buildings has a paramount effect on the total energy consumption. As the existing values in the national standard was determined to be insufficient in terms of energy conservation, the standard was revised in 1998 for new buildings. Table 1 presents the U values according to the building elements in Turkey, USA and some European countries.

Table 1 U values [W/m^2K] according to building elements

	Turkey		UK			Switzerland	
COUNTRY	TS 825	USA	1990	Netherlands	Germany	SBN 80	Sweden
Roof	0.40	0.28	0.35	0.30	0.35	0.25	0.20-0.30
Ex. Wall	0.60		0.60	0.40	0.40	0.38	0.30-0.30
Window	0.28		2.8	3	2.8	2	2
Floor	0.60	0.88		0.5	0.5	0.35	0.20-0.30

Yet, the challenge was to achieve the given energy conservation values in the existing residential buildings. Therefore, the rehabilitation of the external envelopes of existing residential buildings with energy efficient retrofitting systems has gained importance. In this context, a research project was set to develop energy efficient retrofitting systems for the external envelopes of the existing residential buildings in Istanbul, (Özkan et al., 1997).

In the research, the yearly energy consumption for heating was calculated as 213.50 kWh/m^2 for a sample building block with 10 dwelling units. The yearly required energy for heating was calculated to be 60 kWh/m^2 for the sample building according to the revised standard. The given value was achieved in the sample building when it was retrofitted with the systems where the outer surfaces of the walls (EW), roof slab (R) and the cantilever floors (F) were thermally insulated with 8, 10 and 15 cm. thick expanded polystyrene and the single glasses were replaced with clear (G1) or low-e (G2) double glazing -EWFR8G1, EWFR10G1, EWFR15G1 EWFR5G2, EWFR8G2, EWFR10G2, EWFR15G2. Therefore, these retrofitting systems were determined energy efficient for the rehabilitation of the external envelope of the residential building in Istanbul. The energy conserved by the retrofitting systems are presented in Figure 1. The least, 68,81%, energy conservation was provided by the retrofitting system- EWFR8G1 where the system- EWFR15G2 had the highest, 79,67%, energy

conservation value (Sahal, 2000). However, the cost efficiency of the retrofitting systems is in question for the households.

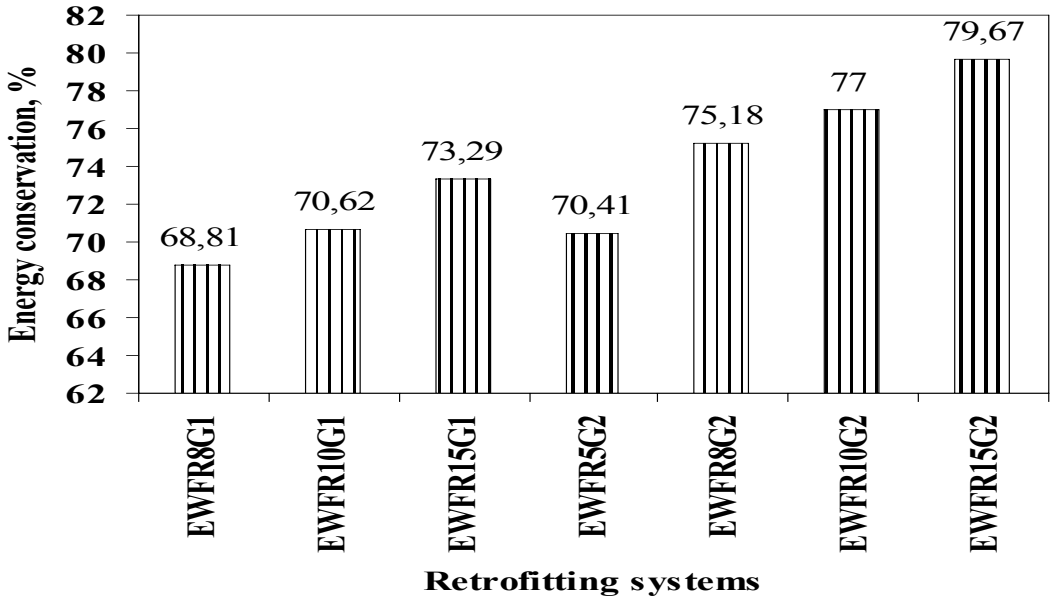

Figure 1: Energy conserved by the energy efficient retrofitting systems

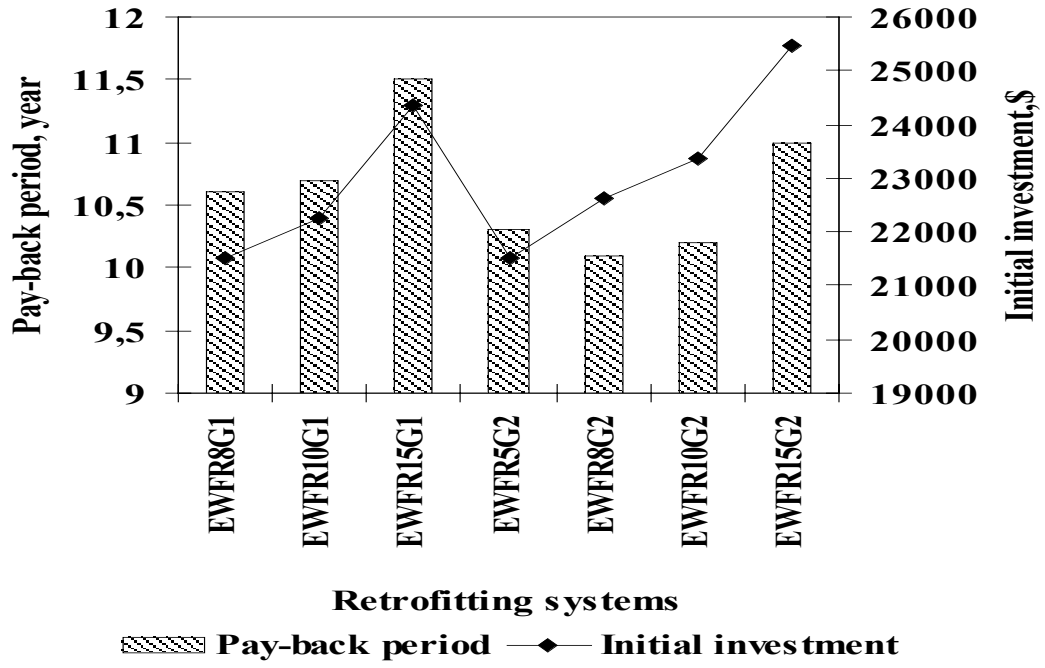

Figure 2 Pay-back periods and initial investment costs of energy efficient retrofitting systems

The initial investment costs for each of the energy efficient retrofitting systems were calculated. The minimum pay-back periods, in which the initial investments are met with the monetary equivalence of energy savings, for each energy efficient retrofitting systems were calculated with an interest rate of 5%, Figure 2. The highest energy savings, 75.18% and the lowest pay back period, 10 years, are provided with the retrofitting system where the opaque components are thermally insulated with 8 cm. material and single glasses in windows are replaced with low-e coated double glazing-EWFR8G2. However, 10 years is considered inappropriate as the pay-back period of the thermal retrofitting of the existing building. In other words, the initial investment cost of the retrofitting (which is $2261 for each housing unit) is unaffordable for the lowest, lower, middle and high income families, considering the yearly incomes of $3473, 5934, 8611 and 12953 for the groups respectively. It seems possible for the highest income group to afford the cost of retrofitting. The average income for a family in the highest income group is $41390. Nevertheless, making the investment for thermal insulation requires encouragement.

Briefly, retrofitting an existing residential building with sufficient thermal insulation is not affordable for the households. Therefore, the government and municipality have to develop new economical policy and implement new economical measures for the households to afford an energy efficient system for retrofitting the existing buildings. One of the economical measures is granting credits with low interest rates to the households for retrofitting. The other measures may include reducing the costs of retrofitting systems by reducing the taxes applied to the thermal insulation and installation materials and developing cost efficient retrofitting techniques.

EARTHQUAKE DISASTER PREVENTION: ASEISMIC BUILDING DESIGN

Turkish land as Anatolia and Thrace as a whole is in a high earthquake risk. Global Seismic Hazard Map prepared according the probability earthquake exceedance of seismic movement for an exposure time of 50 years to 475 years shows that about 95% of Turkish land is in moderate to very high risk with 2.4 – 4.0 m/s and more than 4.0 m/s peak ground acceleration respectively, (Garcia, 2000). In Turkey, about 80 earthquakes with the moment magnitudes - (Mw) over 5.5 have been occurred during 20th century. Two recent earthquake in Eastern Region of Marmara Sea shook 'Kocaeli – Sakarya' (Gölcük) region on the 17th August 1999 and 'Düzce and Bolu' regions on the 12th November 1999 with the moment magnitudes - (Mw) of 7.4 and 7.2 respectively. The seismic force created the ground surface displacement of 5.2 m at maximum. The region is densely populated and highly industrialised. The industry in the region produces 40% of the total GNP and 47 % of value added by the total industry, (Anon. 2000).

The buildings in the region which were either collapsed or hazardously damaged contained 224 000 units of houses, workshops and small factories where 1.5 million people dwelled and worked. Enormous amount of collapsed building construction wastes accumulated on the sites. The waste has been gradually cleared but damped into the sea and the any area where landslides occur. Thus, instead of recycling concrete aggregate and masonry rubbles, the wastes became pollutants for Marmara Sea as well as the surrounding land.

It is assumed according to calculations of periodic seismic events occurred in Turkey that an earthquake with the moment magnitude - (Mw) more than 7.0 will occur in Marmara sea in 30 years time. It is anticipated that it will be the cause of great disasters in the form of destruction of buildings and sub-structure of the settlements surround the northern sides of Marmara Sea including Istanbul. Istanbul is a metropolis with about 10 million inhabitants,

6.5 million of which live in settlements on the seaside. If the prediction is correct the destruction of properties, and loss of life will be effective on economics of the Turkey and the future generations. Therefore, any earthquake with high to very high ground acceleration in any part of the Turkey should be considered disastrous cause on the sustainable development. Kept in mind that durability of a building structure should be sustained throughout its life.

Comprehensive regulation concerning the aseismic design of building structures was first issued 1975 and then 1998. Some of the buildings constructed, since 1975, in regions as Sakarya that shaken regularly by high seismic intensity also collapsed during the recent earthquakes. This occurrence shows that the buildings had not been designed and constructed to perform harmoniously with seismic movement. However, the regulation in force is well developed and covers the seismic design criteria leading to avoid building collapse in high intensity earthquakes. It will be effective, if it is properly applied in practice. The Turkish communities settled in earthquake areas appear that they do habitually build their home in old settlement sites without considering high seismic risk, but also, they are not willing to pay for the excessive cost of buildings with anti-seismic structures. In the professional site, architects, engineers as well as the others who work in the building sector are not well prepared for the proper practice of aseismic building, building, construction and also aseismic retrofitting. Evidently, it requires professional and the public consciousness at first.

In the course of modern architecture era, when an architect designs a building, considers many factors next to basic functions of the prospective building and also a structure that stands up against gravity in the later stage of design process. If the design approaches or architectural forms had been developed in regions as England, Germany, France, Russia, North-Eastern America (except west-cost region), Australia etc. where the probability of earthquake exceedance is low and the lands subject from very low to moderate ground acceleration, earthquakes are not adequately considered. This approach is rational and thus reflected in building regulations and most of the architectural publications and periodicals.

In Turkey, Architectural theories and approaches and architectural forms had been desultorily imported from the Western countries. Therefore, the architects designing buildings have remained to think structures that stand up against gravity without considering high seismic risks thus the internal and external forms of the buildings mismatch the aseismic structures mostly, (Ambrose, 1999). In earthquake regions, when a building is designed, the architect should develop the form with seismic effects in his mind. In the early design stage, two structures that stand against gravitational loads and the laterally effective seismic forces should be considered. Through the design process these two structures can be combined into one and integrated with the forms and the sub-systems of the prospective building.

Considering the conditions in Turkey, aseismic building design education in architecture may be a starting point for the development of the professional and the public consciousness about earthquake. However, a sensitive approach is required. Instead of restricting the formes and shapes of the buildings according to the seismic rules, basic principles can be set that similarly stated in Eurocode-8:

- Using vertical and horizontal frames
- Closed perimeters: internal and external borders
- Symmetry of masses and rigidity: combine centre of gravity with centre of rigidity
- Harmony in dimensional proportion
- Opposing gravity: lightness of dead load and a low center of gravity

- Insulating movement: using concepts and devices that permit minimum impact when the building is subjected to oscillation.
- Elasticity: employing materials with high strength and elasticity that behave uniformly
- Sub-structure solidity: using compact and sufficiently rigid but ductile solutions

The principles do not insist, constrain or impose certain building forms that are referred in some recent publications. However it requires new design approaches in the architectural education.

CONCLUSION

The conditions in Turkey indicate that the energy conservation in the operation of buildings, aseismic architecture, construction of earthquake resistant building and retrofitting of existing buildings and sub-structures are the specific cases for the economy and sustainable development of Turkey.

A research project about energy efficient retrofitting of buildings showed that the initial cost of the energy efficient retrofitting is unaffordable for the most families. Therefore, improving the efficient use of energy and energy conservation remain as an issue of the sustainable development.

Aseismic building design education in architecture may be a starting point for the development of the consciousness about earthquake. Therefore, it requires new and sensitive design approaches in the architectural education considering basic principles that are set according to the seismic rules, instead of restricting the formes and shapes of the buildings.

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Effective technical solutions for sustainable offices -a focus on building materials-

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1. INTRODUCTION

In 1987 the 'Brundtland Commission' released the report 'Our Common Future' in which the definition of sustainable development was an important topic. This definition made a connection between environmental and social goals in the world. In the year 1990 Ehrlich & Ehrlich and Speth re-introduced a formula, which makes it possible to quantify this connection between both goals:

$$\mathbf{EP = P \times W \times E}$$

In this formula EP stands for environmental pressure, which was said to be too high and had to be halved in 50 years from 1990. P stands for the world population, which is predicted to double within 50 years. W stands for the average welfare rate of a world citizen, which is predicted to improve with factor 5 in 50 years. Therefore E, the environmental impact by welfare per citizen, equals:

$$\mathbf{½ = 2 \times 5 \times \underline{1/20}}$$

The calculation shows that by the year 2040 the environmental load has to decrease by 95%, a factor 20.
This factor 20 can be used as a goal and guiding line for the environmental performance of buildings. Aiming at a factor 20 reduction of the environmental load of buildings in the year 2040, it is necessary to focus on aspects that are most effective.

2. EFFECTIVE SUSTAINABLE SOLUTIONS FOR OFFICE BUILDINGS

The environmental load of buildings is caused by the use of building materials, energy, water and employee travel during the life span of the building. From the assessment of different office buildings (van den Dobbelsteen et al. 2002), assuming the life span of buildings is 75 years, it is concluded that the energy consumption (especially the energy consumption for lighting, heating and apparatus) during the life span is responsible for the greater part of the environmental load. This means that in order to diminish the environmental load of buildings the biggest achievement can be made by less energy consumption and of course the application of sustainable (renewable) energy sources.
As shown in figure 1, the use of building materials plays also an important role in the environmental load of a building.

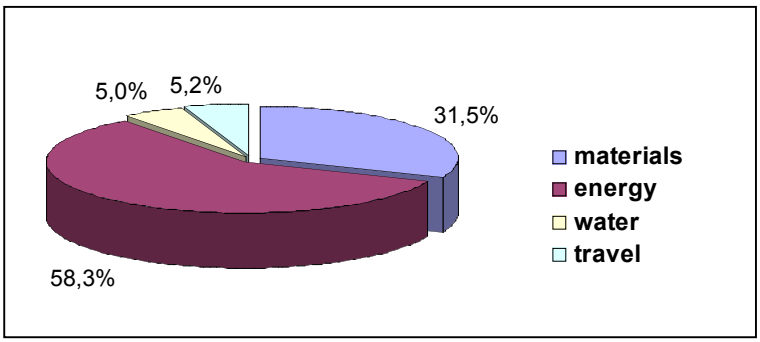

Figure 1 Shares of the environmental load of office buildings.

The share of the contribution of materials to the environmental load of buildings depends on the life span. When a building is constructed a lot of materials are applied; the environmental load caused by the use of these materials is spread over the life span of the building. During the life span maintenance and renovation will occur, which will add to the environmental load. Of course a longer life span means more maintenance, but still the contribution to the environmental load caused by maintenance will be rather small.
The assumption is made that the life span of buildings is 75 years. The environmental load caused by energy, water and employee travel appears yearly; the environmental load caused by building materials arises mainly when the building is built. Therefore, shortening the life span of buildings means that the importance of materials in the environmental load of buildings will increase. This is shown in figure 2.

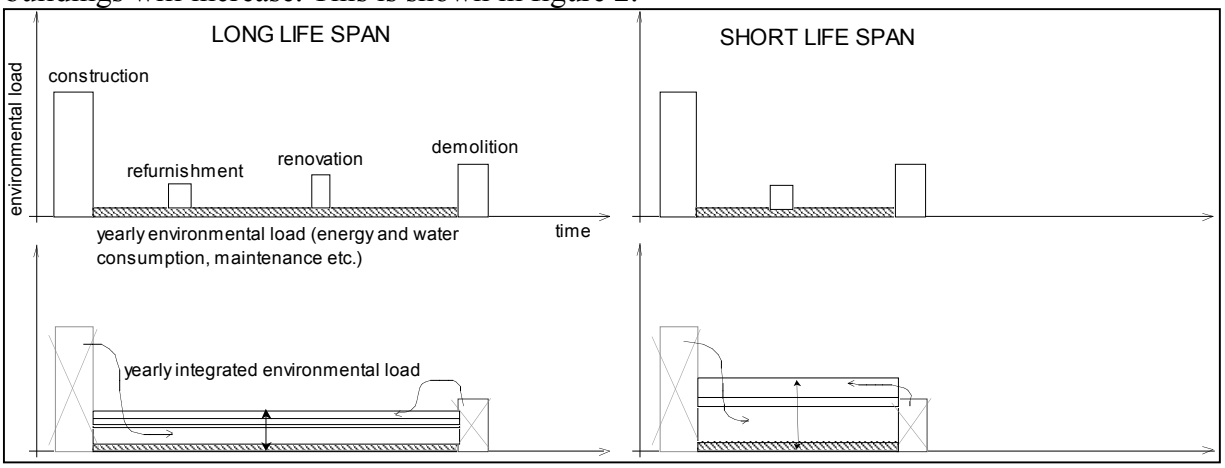

Figure 2 The influence of the life span of a building on the importance of the materials with regard to the environmental load.

Nowadays the functional life span of office buildings is probably not much longer than 25 years, and reducing still, with as a consequence that in offices building materials actually form a more important part of the total environmental load of a building. Therefore it is necessary to find effective sustainable solutions for the material use in (office) buildings.

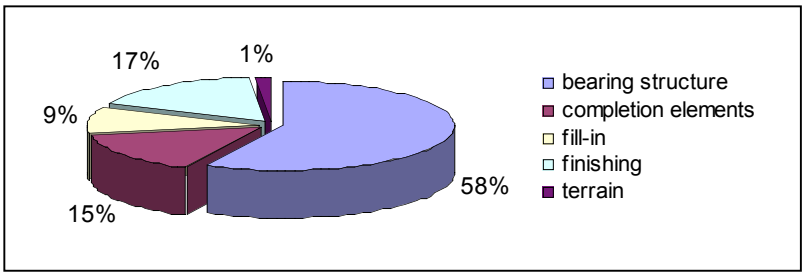

Figure 3 Shares of environmental load caused by building materials

From the assessment of different office buildings (van den Dobbelsteen et al. 2002) it is concluded that about 60% of the environmental load of buildings is caused by the bearing structure (figure 3). Improvement of the bearing structure will lead to a significant improvement of the environmental load of the whole building.

3. IMPROVING THE BEARING STRUCTURE

There are four ways to improve the bearing structure in a sustainable way:

1. finding the best materials given a certain building structure span
2. making optimal combinations of building materials
3. finding new materials for building structures
4. developing innovative solutions for building structures

Improvement of the bearing structure must focus on the most effective solutions, in other words the parts of the building that contribute most to the environmental load.
From the assessment of office buildings it is concluded that horizontal elements of the bearing structure (beams, floor and roof structure) cause about 80% of the environmental load of the bearing structure. Especially the floors (including roof, ground-floor and storey floors) are an important part of the environmental load (Arets 2001).
In de coming paragraphs different floor types for office buildings are assessed in order to find the best floor types given a certain building structure span.

3.1 The functional unity

In order to find the best material or structure variant a functional unity has to be defined. This functional unity forms the basis for comparison of different materials. Without it a proper comparison is not possible.
The functional unity consists of structural, safety and comfort requirements;

- load
- deformation
- dimensions
- fire safety (of the construction)
- thermal isolation
- sound isolation

Before comparing the alternatives, the requirements have to be quantified and the alternatives have to be designed in a way they meet all the requirements.
In order to compare floors, the functional unity is defined (Arets, 2001):

- load: 2,5 kN/m^2 (excl. construction weight)
- deformation: in accordance with the Dutch standards
- fire safety: 120 minutes
- sound isolation: in accordance with the Dutch standards for dwellings
- span: 4,8 to 16,8 m (with steps of 0,6 m), without intermediate beams

3.2 Assessment of different floors for office buildings

In the master thesis 'Environmental comparison of bearing structures' (Arets 2001) the environmental load of different floor types at different spans was determined. These floors are:

- hollow core slab
- composite floor-plate (reinforced)
- composite floor-plate (pre-stressed)
- TT-slab

- steelplate-concrete floor
- bubbledeck floor
- wooden floor

Note that there is an important difference between the bubbledeck floor and the other floors. The bubbledeck floor has a load bearing capacity in two directions. The other floors have a bearing capacity in one direction and beams are necessary to lead the load to the columns, this is shown in figure 4. These beams are not taken into account while determining the environmental load and cost.

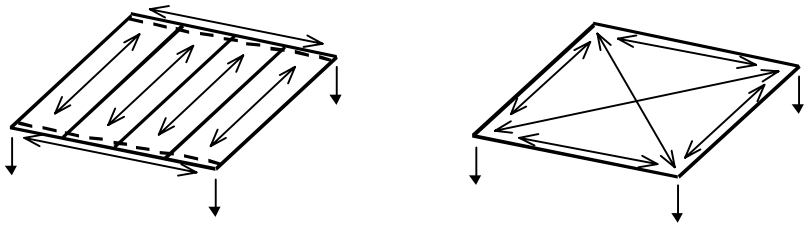

Figure 4: Load bearing capacity of floors in one and two directions

For different spans the dimensions of the floors was calculated meeting the requirements as defined in the functional unity. The wooden floor is equipped with plaster slabs to improve its fire safety up to 120 minutes. All floors have finishings.
Knowing the dimensions of the floors, the environmental load of the different floor types at different spans was calculated. Therefore the database of GreenCalc (a Dutch computer program which calculates the environmental load of buildings; GreenCalc is LCA-based) was used. GreenCalc expresses the environmental load as environmental cost, making it possible to compare the economic and the ecological impact. The environmental cost are the cost necessary to prevent environmental effects and to restore the damage caused by environmental effects.

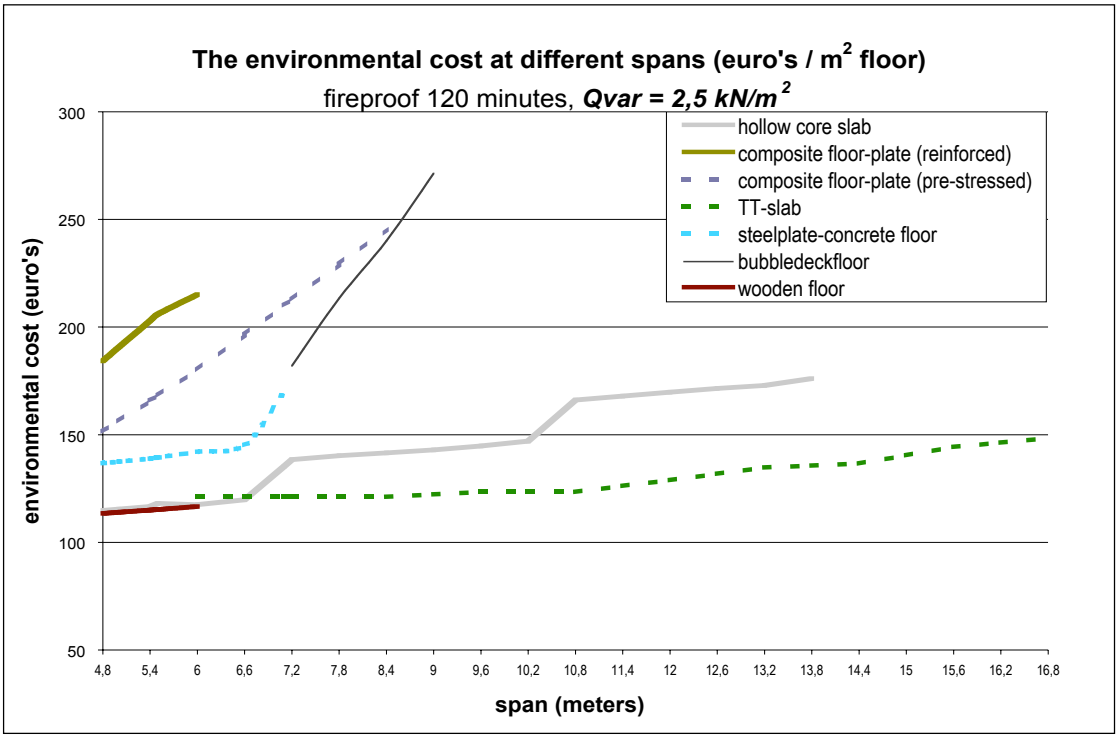

Figure 5: The environmental cost of different floor types at different spans

The results are shown in figure 5. This graphic shows that the wooden floor and the hollow core slab for short spans and for larger spans the concrete TT-slab have the lowest environmental cost. This indicates that, based on the mentioned requirements, from an environmental point of view these floor types are the best for these spans.
But not only the environmental cost is interesting; the economic cost of the different floor types plays an important role in the decision making. Therefore the economic cost of these floors at the different spans was calculated and added to the environmental cost, leading to the integral cost. The integral cost of the different floors is shown in figure 6. When looking at this graphic it is obvious that from environmental and economic point of view for short spans the hollow core slab is the most profitable and for larger spans the TT-slab is the most profitable.

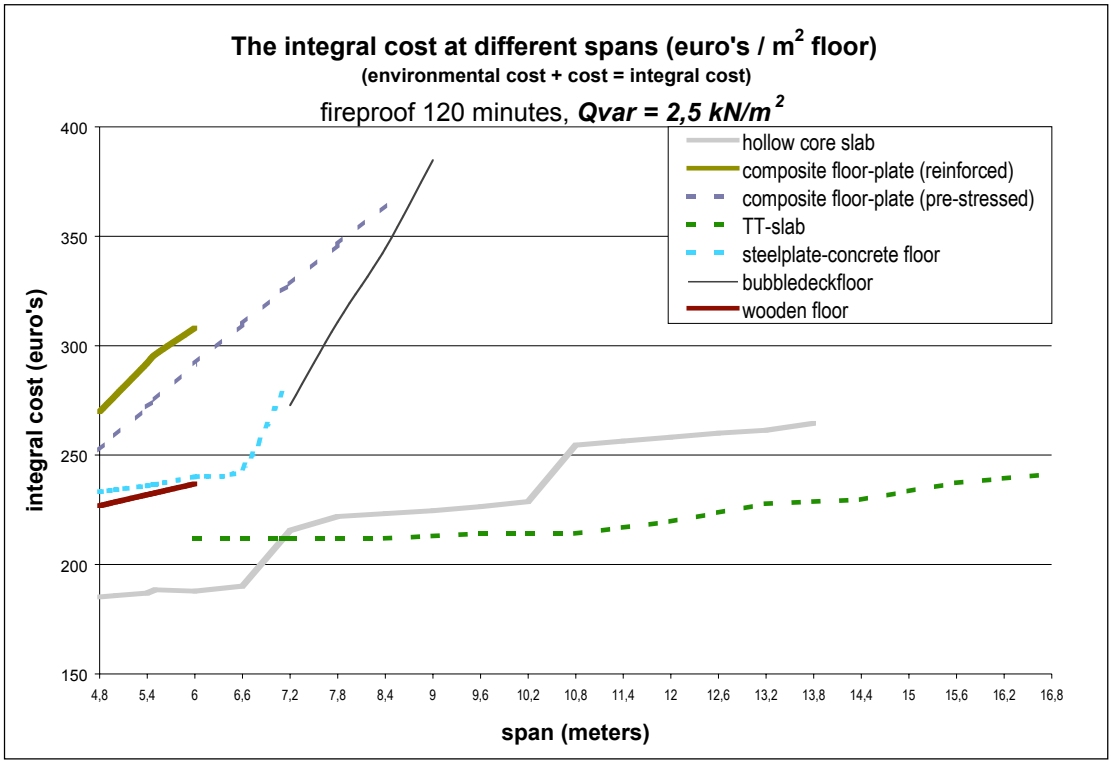

Figure 6: The integral cost of different floor types at different spans

There are a few things to keep in mind:

- these conclusions are only valid for the functional unity as mentioned earlier
- the economic and environmental cost are calculated for the Netherlands
- the cost (environmental and economic) is influenced by made assumptions; therefore it is more important too look at the difference in cost between the floor types than too look at the value of the cost.

3.3 Making optimal combinations of building materials

Concrete, steel and timber are mostly used for the bearing structure. These materials have different qualities with respect to tensile-strength, compression-strength, bending-strength, shear-strength and so on. In order to use as less material as possible it is logical to use a material of which the qualities fit the appearing strain. But to diminish the environmental load there is more than just minimising the use of materials. It is also important that one uses materials with a low environmental impact. The combination of using less material and materials with low environmental impact should lead to the use of the right material for the right function. In order to find out which material should be used from an ecological point of

view the environmental cost of concrete, steel and timber have been calculated for a different type of loading (Arets 2001). The results are shown in table 1, note that the concrete is not prestressed or reinforced. With reinforcing metal the compression-strength and the tensile-strength of concrete get better, but due to the high environmental cost of steel the environmental cost of reinforced concrete increase. If the concrete is pre-stressed, the material qualities will improve more than if it is reinforced, meaning that the environmental cost of pre-stressed concrete is lower then of reinforced concrete

Table 1: Environmental cost (indexed) for different manners of loading

		weight	volume	compression-strength	tensile-strength	deformation by compression	deformation by tension
Concrete	B35	100	200	186	--	124	--
	B65	100	200	100	--	100	--
Steel	Fe E 235	964	620	515	217	571	327
Timber	K24	261	100	160	101	261	101
	K24, glulam	324	124	158	100	259	100

Important for the environmental load of elements of the bearing structure is the shape of the element. As is well know an I-profile is much more effective (for bending, buckling, etc.) than a massive cross-section with the same amount of material.

4. CONCLUSION

In order to achieve a factor 20 improvement of the environmental load of buildings it is necessary to focus on the most effective sustainable solutions. Assuming a life span of 75 years, the energy consumption causes the greatest part of the environmental load. The use of materials causes the second greatest part, but increases when the life span is shorted.
From the assessment of different office buildings it is concluded that about 60% of the environmental load of materials is caused by the bearing structure. Especially the floors (including roof, ground-floor and storey floors) are an important part. Different floor types, meeting the same structural, safety and comfort requirements, have been compared, resulting in a clear overview of best solutions for different structural spans, with which a well-argumented sustainable choice between existing structure solutions can be made.

The mentioned solutions in this article are technical solutions. There are also other ways to achive the factor 20. The use of space and the life span of buildings also play an important role. This is elaborated in 'Effective solutions for sustainable office accommodation – technology, space use and life span'.

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Green building assessment in China: Present and future

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1. INTRODUCTION

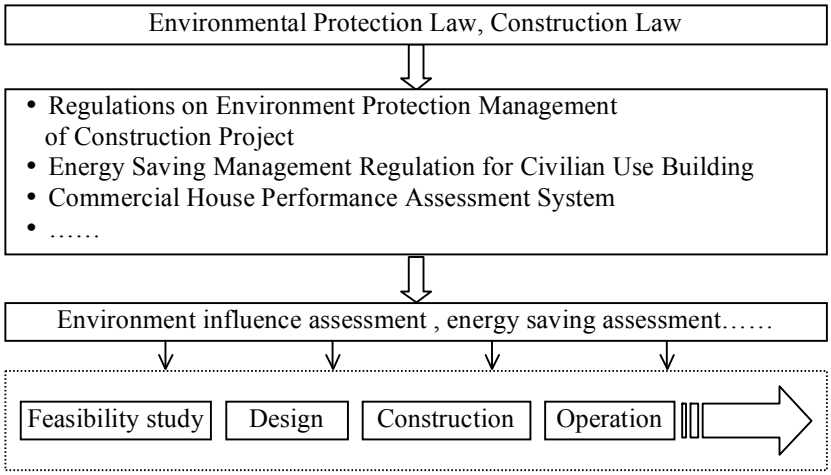
In the long humanity history, building is all along one of the most necessary substance for human being. It is quite difficult to express how much benefit people get from housing. Nevertheless, at the same time when people enjoy their housing, new problems appear. Actually, building is one of the main consumers of natural resource as well as the main producers of environmental loadings. For example, in U.S the construction industry (including infrastructure) is responsible for some 15% of CO_2 equivalent emissions (Hendrickson and Horvath 2000). In the European Union, buildings are estimated to consume approximately 40% total energy, and also to be responsible for some 30% of CO_2 emission, and to generate approximately 40% of all man-made waste (Sjöström and Bakens 1999) Moreover, sick building syndrome reported by persons living in modern houses forces us to think more about what building brings to us besides warmth and comfort. Green building, which is also called sustainable building, then come into being. With the more and more attention being paid by the global building researchers, many international organizations, such as iiSBE, have been founded to push forward the development of sustainable building. One of the achievements in green building research is the foundation of many green building performance assessment systems. For example, the Building Research Establishment Environmental Assessment Method(BREEAM) in U.K , the LEED system built in U.S.A, the QUANTUM in Netherlands, the ECO-PRO in Germany, the EQUER in France and the Athena in Canada etc. These systems have undoubtedly acted as a important director in green building practice.

In China, a country with long civilized history, sustainable development concept has been already identified in the old times. Xun Zi, a philosopher in Chinese history, has systematically put forward the theory that people should have respect for the ecologic rules and attach importance to the sustainable application of natural resources. At present, although there are plentiful resources in China, large amount of population has made the average resource shared by one person relatively low compared with other countries. Therefore, the actualisation of sustainable development should be adopted without delay. The white book which is issued in 1994, with the name of 'The 21 century agenda -Population, environment and development in China', has set out the general strategy and action plan for the sustainable development. In 1996, the Ninth Five Year and 2010 Vista Plan has again made sustainable development as an important strategy for the social and economic development in China. All of these has shown the fact that sustainable development has been paid much attention to by the Chinese government. As a result, in Chinese construction industry many regulations and policies have been made under the direction of the sustainable strategy.

2. GREEN BUILDING ASSESSMENT IN CHINA: CURRENT SITUATION

2.1 Overview

The Environmental Protection Law and the Construction Law can be taken as the basic foundation of green building in China. Shown in Figure 1, on the base of these two laws, many regulations and rules have been made in different profiles of green building assessment, such as the Regulations on Environment Protection Management of Construction Project, the Energy Saving Management Regulation for Civilian Use Building and the commercial house performance assessment institution etc. These regulations and institutions have taken great effect on the green building assessment for the life-cycle of a construction project.



Figiure1 Foundation of green building assessment in China

2.2 Environmental influence assessment

One important part of the green building assessment in China mainly concentrates on the environmental influence assessment of construction project. Especially on the environment loadings analysis and evaluation. Based on such an assessment system, the environment influence of a project can be identified. This assessment work is usually done in the feasibility study phase of a project. If a construction project has the possibility of great influence to the environment, an environmental influence report book must be made. The report should include the following content:

- Project background
- Current environmental situation of the project surroundings
- Analysis and prediction of the project environmental influence
- Economic and technical evaluation to the measures for environmental protection
- Cost and benefit analysis for project environmental influence
- Suggestions for the environmental monitor of the project
- Conclusion of the environmental influence assessment

According to the conclusion of the environmental influence assessment, project which has a bad environmental performance can not be constructed. This environmental assessment system has successful prevent the natural environment from being destroyed by the construction project. The Regulations on Environment Protection Management of Construction Project, which is issued in 1998, has a definite description of the requirement in detail.

2.3 Energy saving assessment

With the rapid development of Chinese economy, large amount of energy consumption has made the government pay much attention to the energy saving problem. This can be demonstrated by the enactment of the Energy Saving Management Regulation for Civilian

Use Building in 2000. From then on the green building assessment has formally added the content of energy saving assessment especially in the feasibility study phase of a project. According to the regulation, the feasibility study report or design task book of a new civilian use construction project must have the specific analysis and assessment of energy saving performance of the building. If the energy saving performance is not good, the project can not be permitted for construction. Furthermore, the project design must obey the energy saving design standard. If it is not fit for the energy saving standard, the design alternative must be changed. At the same time, the energy saving performance assessment of construction inventory has been gradually put in force. And the application of energy saving technology is strongly recommended.

2.4 Green building assessment in the commercial house performance assessment system

Recently, the execution of the commercial house performance evaluation institution has push the green building assessment on a high level. Performance assessment for commercial house is a very important institution in Chinese construction industry. The purpose is to eliminate the asymmetric phenomenon in the housing transaction process and regularize the housing market. According to this institution , the commercial house which has been built up must be evaluated using the performance assessment system and labelled a bank before it is put into the housing market. So the purchaser can directly identify the quality of the house according to the bank. The assessment system for commercial house consists of five indicators, including applicability, safety, durability, environment and economic performance. The environment and economic performance has directly reflected the green building performance. In detail, the environmental performance includes the sub indicators list below:

- the reasonableness of planning
- water hygiene
- green grass allocation
- outdoor noise and air quality

And the economic performance includes:

- operation energy consumption
- maintenance cost

Besides these two direct indicators, there still some sub-indicators in the other three performance categories which have shown the green building concept. For example, the heat preservation and adiabatic performance , which is one sub indicator of applicability, also reflect the energy saving performance of the building. And the Prevention from poisonous and harmful substance sub indicator of safety, can also reflect the green performance of a building.

2.5 Other assessment systems

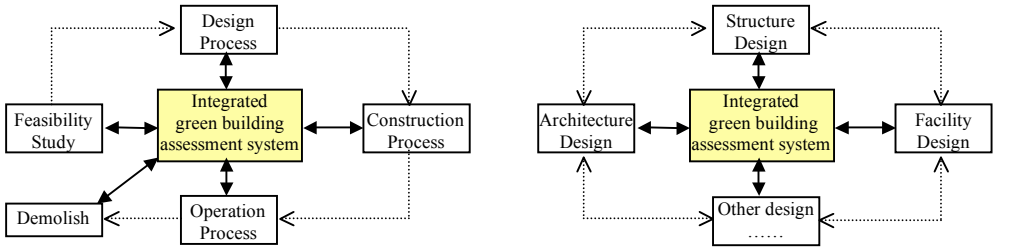
Apart from the assessment of environment influence and energy saving, with more and more inhabitants identify that building has an important influence on people's health, the indoor environmental quality healthy monitor also begin to be used to the building product. For example, the detection and assessment of specific radiation and inner air quality has come into being. As a result of market demand, many companies or organizations which engage in indoor environmental quality detection have been set up.

In addition to the environment assessment of building itself, the assessment of the construction process has also been assessed. For instance, according to the Construction Law, the construction company should control and deal with the environmental pollution caused by dust, waste air and water, garbage and noise in the construction site.

3. CONSTRUCTION AND IMPLEMENTATION OF GREEN BUILDING ASSESSMENT SYSTEM: FUTURE TASK

3.1 Construction of green building assessment system: from segregation to integration

According to the introduction in the second part, we can find out the former green building assessment systems exist almost every phase of project construction process. However, these building assessment regulations and systems separate with each other. There still lack of a systematically unified project life-cycle green building assessment system at present. The shortcomings is that , depending on isolated systems, we can only get the partial optimising alternative for a certain phase, but not the global optimising one for the life-cycle of the construction project. For example, we choose the best design alternative according to the environment influence of the project, but from energy saving point view, it is usually not the best one. Even can it be the worst one. Green building is a multi-object optimisation process. Therefore, it is necessary to build an integrated system for green building assessment. The green building assessment integration has two meaning. One meaning is that green building assessment should integrate different phases of the project life-cycle. As shown in figure2(a), the green building assessment system should include the feasibility, design, construction, operation and even the demolish process of construction project. To build such a integrated system, the cooperation of the experts in different construction process is needed. In other words, the economic and environment expert in feasibility study phase, the design consultant expert in design phase, the construction expert in construction phase and the expert in project



(a) Integrated system of project life-cycle (b) Integrated system of different design specialities

Figure 2 Integrated green building assessment system

operation and demolish phase should be together to construct a green building assessment system for the life-cycle process of the construction project. With the help of such an integrated system, any decision in different phase of a certain project can be made from a life-cycle multi-object sustainable building optimisation standpoint. The other meaning is the integration of different specialities. For example, in the design phase of a construction project, which play an important role to realize sustainable construction, we need architecture, structure engineer, facility engineer and so on. During the process of green building design, if they only pay attention to the assessment system of their own major, it is unavoidable to take some adverse effect to other domain. For example, when the architecture choose a walling material which is excellent for energy saving, maybe it is not good for the structure bearing capacity. Therefore, to build green building assessment system which integrate the information of different specialities, shown in figure2(b) is also in dire need.

3.2 The object of green building assessment : No only new buildings but also old ones

In addition to the integration of green building assessment systems, another thing should be pointed out is that the assessment system should not only include the new buildings but also the old ones. Formerly, the object of green building assessment in China mainly concentrates on the new building. Take the performance assessment system for commercial house for

example, the time of assessment is when the building has just been built and will put to the housing market. In fact, large amount of existing old buildings are also playing an important role in green building field. For instance, bad sewage system of old buildings can make big trouble to environment. And inferior heat preservation performance because of the poor envelope system of old buildings can also cause large quantities of energy waste. Furthermore, in some of the old residential districts, the indoor air quality is much worse. Therefore, green assessment system for such building should also be carry out. There are two obvious benefits to build such a system. First, based on a green performance assessment system, we can have a clear understand about the green character of a certain building, which can help us have a more reasonable maintenance and renovation plan for it. Secondly, also through a green performance assessment system, we can identify the green performance of all the buildings of a city or a certain urban district, which can help us make a more efficient policy for sustainable urban renewal and development.

3.3 Implementation of the assessment system: from passive reception to initiative action

Indeed, the implementation of green building assessment system is not less complicated than the construction of such a system. In a manner of speaking, the green assessment system is formerly a passive reception system, which is shown in figure3(a). The law and regulation has been made by the government. And the real state broker, the designer and the general contractor, who play an important role in the green building implementation, usually passively accept the laws and regulations. In other words, they just separately pay attention to

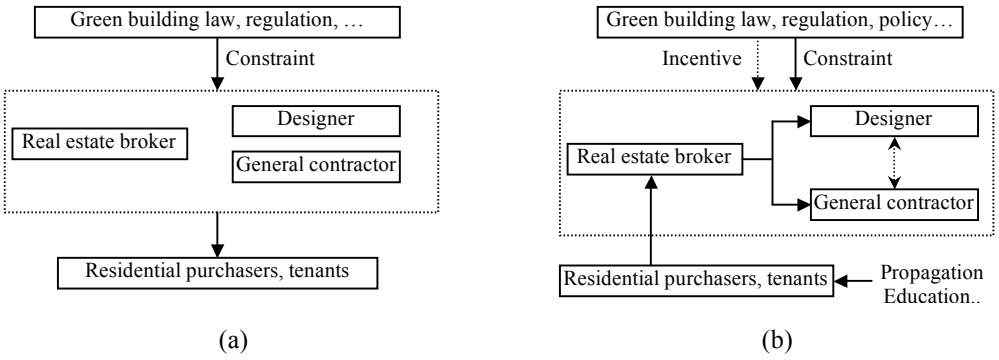


Figure 3 Implementation of green building assessment

the restrictions with regard to their corresponding responsibilities in the green building laws or regulations and try to make sure they obey the rules so that they will not be punished. As long as the project meets the demand of the green building rules, they usually do not want to spent much time thinking about how to get better design alternatives from the sustainable construction point of view any more. At the same time, the purchasers also passively accept the real estate because they lack of the knowledge and awareness of the importance of green building.

To change from such a passive reception system to an efficient initiative action system, two measures are suggested. Shown in figure3(b), the first way is that the government should use suitable tax policy to provide incentive for green building implementation. For example, if the real estate company adopts green building methodology in their project, they will have a tax reduction. Then the real estate company, which is the main director of planning, design and construction of a real estate project, will ask the designer and general contractor to choose optimising design and construction alternatives following green building concept. The same

incentive policy can also be used to design consultant and construction company. Another way is to increase the propagation and education of the green building idea, through which the purchasers can identify the importance of sustainable construction and understand the green building performance of a building. Then they will choose their houses more deeply based on the green building standard. As a result, the market will let the real company actively think more about using green building assessment in the process of project planning, design, construction and so on.

4. PERSPECTIVE

Green building has been widely accepted as one of the most important development strategies for construction industry all over the world. In China, with the largest population in the world, green building is absolutely a wise choice for the development of the country. At present, the rapid progress of Chinese economy, the improvement of people's sustainable development consciousness, the enhancement of international cooperation in sustainable construction field, have provided a good environment for the development of green building. Undoubtedly, green building will make great progress in China in the near future.

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Evaluation of Double Skin Glass Facades in terms of Cost Efficiency with respect to Energy Consumption

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1. INTRODUCTION

Today as a result of gradual depletion of natural energy sources and rising CO_2 emissions due to excessive fuel consumption, the subjects related to energy demand and environmental consciousness are being considered intensively in facade design. On this account an approach becomes necessary that takes into consideration climatic design, energy efficiency and sustainability concepts. With this approach building facades acquire an intelligent skin. Battle, G. and McCarthy, C. pointed out that the skin can perform the function of balancing between internal and external climate by regulating energy flow, collecting and storing energy, distributing the energy where required (Boyd 1994). Briefly, an intelligent skin should serve to decrease energy consumption and support mechanical systems in achieving optimum comfort conditions. Double skin glass facade is one of the intelligent skins designed for performing these functions by using natural energy resources, i.e. wind and sun.

Double skin glass facades are composed of two glass panes and a cavity inbetween. The width of this cavity ranges between 200-1500 mm. Heat losses are minimum through the facade. Sometimes solar control devices are installed into the cavity to prevent solar gain. Daylight can easily be obtained in deep spaces. Such a facade allows to open windows, even on high buildings, so the ventilation provided by fresh air results in decreasing running cost and energy consumption of the air conditioning system (Evans 1997). Consequently, the amount of energy needed for heating, cooling and lighting can significantly be reduced. Also from the viewpoint of the building owner the investment made for the facade is expected to be ecomomical. For this reason, this paper aims to evaluate double skin glass façade in terms of cost efficiency with respect to energy consumption. In the result of this evaluation where the total life cycle costs of different skin configurations are compared the most efficient configuration can be selected.

2. METHOD

For the evaluation, a simulation is done for the double skin glass façade of an office building assumed to be in Istanbul. The energy consumption for each skin configuration is first computed with WIS and ENER-WIN simulation programs. And then to investigate their cost efficiency Life Cycle Cost (LCC) analysis is used, which is one of the techniques used in evaluating energy conservation investments by taking into account the initial cost, savings in use and change in the monetary value over time. The WIS program has been developed by the teams cooperating in the European research project ‘Advanced Windows Information System’ (the project WIS), under the coordination of TNO Building and Construction Research, with financial support from the European Commission (DGXII) (Dijk 1996). The ENER-WIN

program (Energy Calculations – Windows version) has been developed by Texas A&M University, with financial support from the DOE (Degelman 1999). In this paper, WIS is used for computing the heat transmission coefficient (U value) and total solar energy transmittance (g value) of skin configurations. These values become the inputs of the ENER-WIN program for estimating their energy loads. After the energy costs are calculated using energy load values obtained by the simulation, the total life cycle costs as the sum of the energy costs and construction costs are calculated. Consequently, the configuration with the lowest total life cycle cost is selected as the most cost efficient alternative.

3. SIMULATION

The simulation is done for a 30 storey office building in Istanbul. It is assumed that building is enclosed on all facades by a double skin glass façade with a 900mm. cavity. The external and internal skin are structural silicone and transparent, respectively. This building is simulated following the steps described below.

3.1. Arranging the Data

The data needed for computing the U and g values of the alternatives are seen on the Table 1. These belong to transparent components, frame and spacer. Clear glass and low emissivity (low–E) glass are selected for the simulation because of their frequent usage in double skin facades. The values related to the glass in this table are provided by a firm producing building glass in Turkey. The others have been selected from the library of the program, which are the standard values stipulated by CEN (European Committee for Standardisation).

Table 1 Data for computing U and g values.

ENVIRONMENTAL DATA			
Temperature	Outdoor	10°C	
	Indoor	20°C	
TRANSPARENT SYSTEM			
Pane Type		Clear Glass	Low-E Glass
Thickness		6mm.	6mm.
Emissivity	Outdoor	0.840	0.100
	Indoor	0.840	0.840
Solar reflectance	Outdoor	0.070	0.218
	Indoor	0.070	0.144
Visual reflectance	Outdoor	0.080	0.041
	Indoor	0.080	0.055
Solar Transmittance		0.770	0.574
Visual Transmittance		0.880	0.825
The width of the cavity		900 mm.	
Gas form in the cavity		Air	
Solar Shading Device		Venetian blind	
FRAME and SPACER			
Frame type	Metal with 16 mm. thermal break		
Spacer type	Aluminium spacer		

The data needed to run the ENER-WIN program is composed of weather data and the data for the description of the sample building. Weather variables used by the program are latitude, longitude, standard time meridian and elevation, the monthly average of dry bulb temperatures, dew point temperatures, horizontal solar radiation, wind speed and daily maximum temperatures, and standard deviations of these monthly average values. The other data needed to compute the heat gain/losses resulting from the façade are in Table 2.

Table 2 Data for computing heat gain/losses.

BUILDING PROPERTIES		* WINDOW PROPERTIES	
Building Type	Office	Heat transmission coefficient (U value)	
Building Size	36m x 36m	Total solar energy transmittance (g)	
Number of Floors	30	Emissivity	
Ceiling Height	3.30 m.	Daylight Transmissivity	
Total Facade Area	13896 m^2	* The values related to window properties are the outputs of WIS program.	
Total Floor Area	38880 m^2		
Exterior Shading	No	HVAC SYSTEM	
Surface Exposure	Concrete	Air Conditioning System	Fan coil units
Natural Ventilation	Yes	Heating System	Gas
Seasonal Indicator	Summer	Infiltration Rate	0.4 ach**
	Winter	** ach: Air changes per hour	

3.2. Forming Skin Alternatives

In the forming of the skin alternatives (See Table 3), the following variables are taken into consideration:

- The positions of the clear and low−E glass,
- The positions of single and double glass,
- Whether or not the façade has venetian blinds.

3.3. Computing and Evaluating U and g Values of the Alternatives

The U and g values of the double skin configurations formed according to the type and position of the material and the usage of solar shading device are computed by WIS program. The results in Table 3 reveal that the U and g values of the configurations with the venetian blinds are lower than those without. In the case of using the low−E glass on the external skin, there is a noticeable decrease in the U value. It is also possible to say that the best configuration is formed with the use of the low−E glass both on external and internal skin because of the lowest U and g values.

3.4. Computing and Evaluating Annual Energy Loads of the Alternatives

The monthly heating and cooling loads of the skin configurations are first computed with ENER-WIN program depending on the variation of their U and g values. Then the annual energy consumption per square meter of floor area for the alternatives is calculated. It can easily be seen on Table 3 that the best configuration in terms of energy consumption is formed with the use of the low−E glass both on external and internal skins. It is also possible to say that the position of the low−E glass does not significantly affect annual energy consumption.

3.5. Determining the Construction Costs and Life Cycle Energy Costs of the Alternatives

The unit area of any component forming the skin is multiplied by its cost per unit to determine the construction costs of the alternatives. These components are external glass panel, internal glass panel, cat way, solar shading device, structural frame, opaque panel with heat insulation, sound insulation and fire insulation. The unit costs of the components include the material, production and assembly costs. These values are the average of the unit costs taken from three firms constructing curtain walls in Turkey, The construction costs calculated for all the alternatives are shown in Table 3.

The life cycle energy costs are calculated depending on energy consumption, energy unit costs and change in the monetary value over time. In the calculations the life cycle period

assumed for the façade is 30 years. Using discount rate and time, the future energy costs are equated to the present. On Table 3, these values are viewed.

Table 3 WIS and ENER-WIN simulation results for the double skin glass façade alternatives.
Single Glass (SG), Double Glass (DG), Clear Glass (CG), Low-E Glass (LEG).
Heat Transmission Coefficient (U), Total Solar Energy Transmittance (g).
Annual Energy Consumption (AEC).
Life Cycle Energy Costs (LCEC), Construction Cost (CC), Total Life Cycle Cost (TLCC).

No	External Skin	Air Gap (mm)	Internal Skin	U (W/m^2K)	g Factor	AEC (kWh/m^2)	LCEC $ (million)	CC $ (million)	TLCC $ (million)
1.1	SG – CG	N0	SG – CG	2.90	0.55	128.27	0.56	2.75	3.31
1.2	SG – CG	YES	SG – CG	2.64	0.22	124.93	0.49	3.47	3.95
2.1	SG – CG	N0	DG – CG	2.21	0.47	107.72	0.47	3.04	3.50
2.2	SG – CG	YES	DG – CG	2.09	0.17	110.03	0.41	3.76	4.17
3.1	SG – CG	N0	DG – LEG	1.93	0.39	98.44	0.38	3.14	3.52
3.2	SG – CG	YES	DG – LEG	1.86	0.14	102.59	0.36	3.86	4.22
4.1	DG – CG	N0	SG – CG	2.20	0.47	107.05	0.46	3.00	3.46
4.2	DG – CG	YES	SG – CG	2.09	0.27	107.26	0.43	3.72	4.15
5.1	DG – LEG	N0	SG – CG	1.82	0.38	94.47	0.37	3.13	3.50
5.2	DG – LEG	YES	SG– CG	2.02	0.25	105.73	0.40	3.85	4.25
6.1	DG – CG	N0	DG – CG	1.86	0.42	95.25	0.39	3.29	3.69
6.2	DG – CG	YES	DG – CG	1.79	0.22	97.10	0.36	4.01	4.37
7.1	DG – CG	N0	DG – LEG	1.70	0.35	90.86	0.34	3.39	3.74
7.2	DG – CG	YES	DG – LEG	1.66	0.18	92.86	0.32	4.11	4.44
8.1	DG – LEG	N0	DG – CG	1.62	0.34	87.99	0.33	3.38	3.71
8.2	DG – LEG	YES	DG – CG	1.76	0.21	96.63	0.35	4.10	4.44
9.1	DG – LEG	N0	DG – LEG	1.50	0.30	84.23	0.30	3.48	3.79
9.2	DG – LEG	YES	DG – LEG	1.61	0.17	91.54	0.32	4.20	4.52

3.6. Calculating and Evaluating the Total Life Cycle Costs of the Alternatives

The total life cycle cost is defined as the sum both of construction cost and the life cycle energy cost that are determined depending on energy loads, energy unit costs and change in the monetary value over time. Maintenance costs are not added to the total cost because there is no available accurate data about the life cycle period of these facades.

As it is clearly seen in Table 3, the construction costs are about 83 - 92% of the total life cycle costs. Using the venetian blind also increases the construction costs by about 15-20%. In addition, the use of low-E glass on both skins instead of clear glass increases the total cost by 2.71 % while it decreases the life cycle energy costs at the rate of 2.65 %.

3.7. Evaluating the Cost Efficiencies of the Alternatives with respect to their Energy Efficiencies

For this evaluation the energy and cost efficiency of all the alternatives are determined by comparing to the alternative with the lowest energy consumption or total life cycle cost. These values are arranged in Figure 1 according to their efficiency percentage. As it is seen the most energy efficient alternative does not have the lowest total life cycle cost. For instance, although the Number 9.1 which is formed with double low-E glass of both skins is

52.29% more energy efficient compared to the Number 1.1 that has the highest energy consumption, it is 17.17% less cost efficient compared to the same alternative. The most cost efficient alternative is the one (Number 1.1) that is formed with single clear glass on both skins. This is, however, the least efficient alternative in terms of energy efficiency. In addition, the cost efficiency of the alternatives with blinds is lower than those without because of an increase in the initial investment cost.

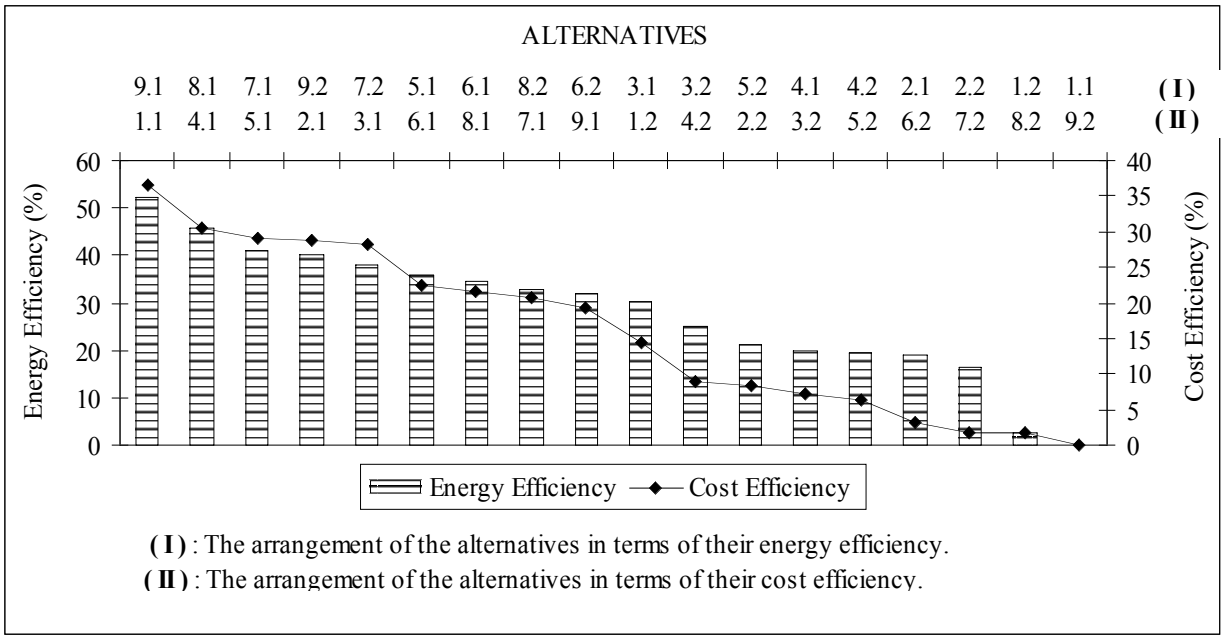

Figure 1 Arranging the alternatives in a row in terms of their energy and cost efficiencies.

4. CONCLUSION

This paper aims to evaluate the double skin facade alternatives formed with different configurations of the skin components in terms of cost efficiency with respect to energy consumption. As a result of this investigation, the configurations formed with double low-E glass are determined as the most energy efficient alternatives, but their total life cycle costs are higher when compared to the configurations formed with single clear glass because of high construction costs. The decision depends on the economic investment from the viewpoint of the building owner and also on conservation of natural energy sources. This subject can be investigated further in future studies. Thus, the determination of the most effficient alternative will be possible.

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Thermal Environment and Exergy Analysis of a Ceiling Radiant Cooling System

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1. INTRODUCTION

Well water is one of the natural resources in our immediate environment with a potential for use in cooling building interiors. Because its temperature is lower than that of outdoor air, it has 'coolness' during the summer season and can be used in radiant cooling systems. The purpose of this study is to utilize the concept of exergy to discuss the meaning of well water 'coolness' applied to a ceiling radiant cooling system. The effect of outdoor shading on thermal environment and cooling system efficiency is also studied. A house in Chiba, Japan, was equipped with a ceiling radiant cooling system using well water, and with outdoor sunshading on the South-facing window. We conducted measurements of indoor thermal environment and electric power consumption in the summer of 2001, and compared these different types of energy by means of exergy analysis.

2. SYSTEM DESCRIPTION

2.1 The house with a ceiling radiant cooling system

The ceiling radiant cooling system was installed in the living room (Fig.1, right hand side) of a two-storey wooden house, which has well-insulated exterior walls and double-glazing windows. The living room window (W: 3.6 m x H: 2.2 m) faces south.

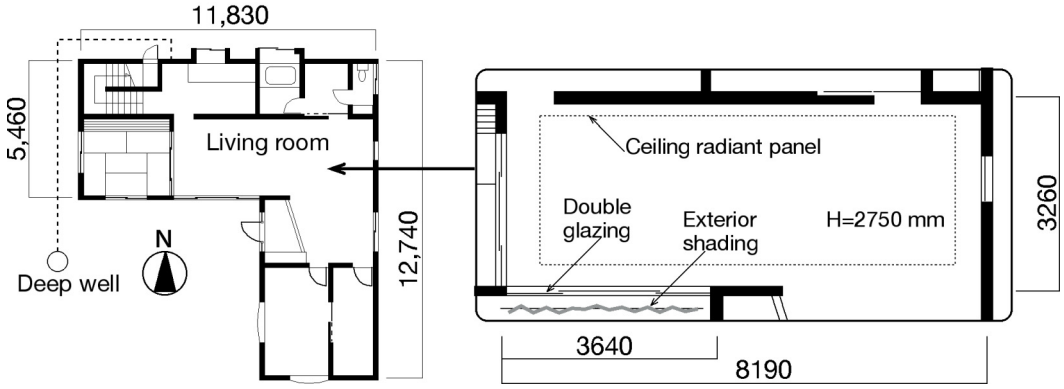


Figure 1 The house equipped with ceiling radiant cooling system using well water.

2.2 Overview of the ceiling radiant cooling system

Figure 2 schematically shows major components and well water flow in the ceiling radiant cooling system: deep well (depth: 66 m), well water pump, three-way valve, circulation

pump, ceiling radiant panel (aluminum panel with embedded pipes), and percolation well. Water from the deep well is pumped up and mixed with return water from the ceiling radiant panel by the three way valve to maintain the temperature at a the set point. The circulation pump enables this mixed water to run within the panel and cool it. A portion of the return water is sent to the three-way valve and the rest is discarded via the percolation well.

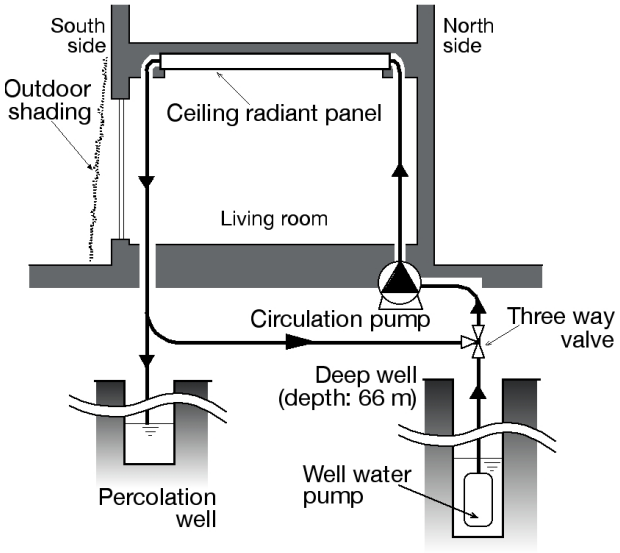


Figure 2 Components and well water flow

3. EXPERIMENTAL SETUP

We did measurements on indoor thermal environment and energy use measurements for the ceiling radiant cooling system during the summer season in Japan (see Table 1).

We measured ca. 80 points and used a digital data recorder to log data at one-minute intervals. Measurements were carried out with and without outdoor sunshading (marsh reed screen; Japanese *Yoshizu*) on the South-facing window. When applied, sunshading was used during ceiling radiant cooling system operation hours, from 10:00 to 16:00. The radiant panel surface temperature was set at 22ºC.

Table 1 Measured items

place	measured items
outdoors	temperature, relative humidity, solar radiation
room interior	room air temperature (FL+0.4, 0.8, 1.2, 1.6, 2.0, 2.4, 2.75m)
	surface temperature (floor, ceiling, glass pane)
	globe temperature (2 points at FL+1.2m)
	relative humidity, wind velocity
water pipe	temperature (3 points at the valve, in & out water temp. at the radiant panel)
	flux (in & out of the valve, supplied water to the radiant panel)
well	temperature, flow rate of pumped up water
pump	electric power supply (water pump, circulation pump)

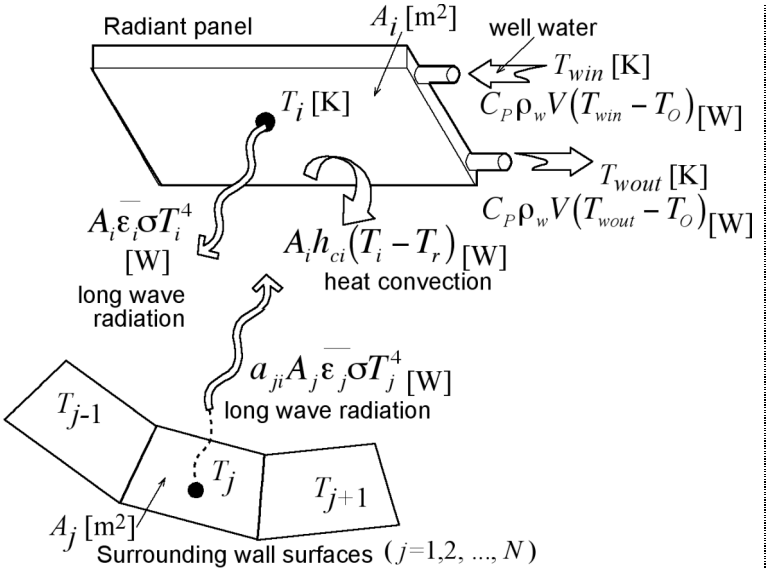
4. EXERGY ANALYSIS

Exergy is a concept to show the ability of dispersion of energy or matter. Using exergy, different types of energy, such as solar radiation, thermal energy, electricity, fossil fuel, etc, can be explicitly shown as 'exergy consumption' and can be compared to each other [1].

To calculate exergy consumption at various parts of a system, we first divide it into several subsystems. Each of the subsystems is a place or device where exergy is consumed as a consequence of energy transfer or energy conversion [2]. We divided the ceiling radiant cooling system into four subsystems: well water pump, three-way valve, circulation pump, and ceiling radiant panel. We, then, set up energy, entropy, and exergy balance equations for each subsystem.

As an example, we show energy and exergy balance equations for the 'ceiling radiant panel' subsystem. Equations for the other subsystems were set up in a similar manner.

Figure 3 shows energy flows for a ceiling radiant panel.



Cp: specific heat of water [J/(kg·K)]
ρw: density of water [Kg/m^3]
V: volume of water flows into the panel [m^3/s]
T_O: environment temperature, usually it is outdoor air temperature [K]
Ai (Aj): surface area of radiant panel (surrounding wall) [m^2]
εi: emissivity [-]
σ: Stephan-Boltzman constant [W/(m^2 ·K^4)]
aij: absorption factor [-]
Ti (Tj): a temperature of radiant panel (surrounding wall) surface [K]
h_{ci}: convection heat transfer coefficient [W/ m^2]
Tr: room air temperature [K]

Figure 3 Energy flow of a ceiling radiant panel

Well water flows into the radiant panel at temperature T_{win} [K] and flows out at T_{wout} [K] ($T_{win} < T_{wout} < T_i$). The radiant panel surface emits long-wave radiation and receives long-wave radiation emitted by surrounding wall surfaces ($T_i < T_j$). Heat transfer between radiant panel surface and room air is also considered ($T_i < T_r$). Eq. 1 shows the respective energy balances.

$$C_P\rho_w V(T_{win}-T_O)+\sum_{j=1}^{N}A_j a_{ji}\varepsilon_j\sigma T_j^4 = C_P\rho_w V(T_{wout}-T_O)+A_i h_{ci}(T_i-T_r)+A_i\varepsilon_i\sigma T_i^4 \quad (1)$$

The energy balance (Eq. 1) is arranged with input terms on the left hand side, and output terms on the right hand side. The first term on the left hand side accounts for the thermal energy content of the well water entering the radiant panel. The second term accounts for the long-wave radiation emitted by surrounding walls. The first term on the right hand side accounts for the thermal energy content of the well water exiting the radiant panel. The second term accounts for the convection heat flux between radiant panel and room air. The third term accounts for the long-wave radiation emitted by the radiant panel surface. We substituted ($A_j a_{ji}\varepsilon_j = A_i a_{ij}\varepsilon_i$) in the second term of left hand and then added (- $A_i\varepsilon_i\sigma T_O^4$) to both sides of equation 1 to obtain the energy of long-wave radiation based on environment temperature T_O [3].

The energy balance equation becomes

$$C_P\rho_w V(T_{win}-T_O)+A_i\varepsilon_i\sigma\sum_{j=1}^{N}a_{ij}\left(T_j^4-T_O^4\right)$$

$$= C_P \rho_w V \left(T_{wout} - T_O\right) + A_i h_{ci} \left(T_i - T_r\right) + A_i \varepsilon_i \sigma \left(T_i^4 - T_O^4\right) \qquad (1)'$$

The corresponding exergy balance equation is given as follows.

$$C_P \rho_w V \left\{ \left(T_{win} - T_O\right) - T_O \ln \frac{T_{win}}{T_O} \right\} + A_i \varepsilon_i \sigma \sum_{j=1}^{N} a_{ij} \left\{ \left(T_j^4 - T_O^4\right) - \frac{4}{3} T_O \left(T_j^3 - T_O^3\right) \right\} - e_{crp}$$

$$= C_P \rho_w V \left\{ \left(T_{wout} - T_O\right) - T_O \ln \frac{T_{wout}}{T_O} \right\} + A_i h_{ci} \left(T_i - T_r\right) \frac{\left(T_i - T_O\right)}{T_i} + A_i \varepsilon_i \sigma \left\{ \left(T_i^4 - T_O^4\right) - \frac{4}{3} T_O \left(T_i^3 - T_O^3\right) \right\} \qquad (2)$$

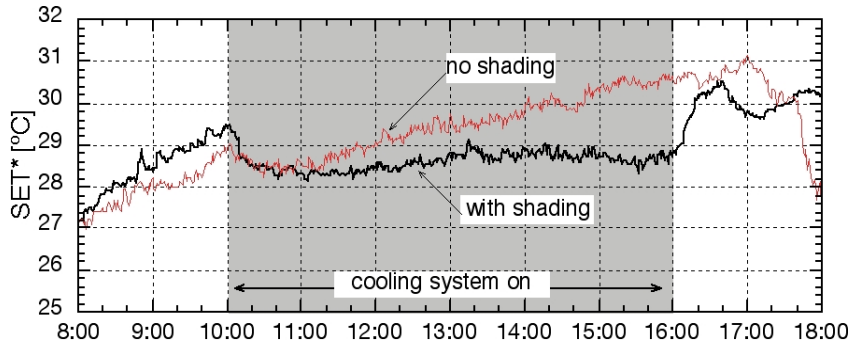
There appeared a term of exergy consumption, e_{crp}, on the third term of left hand side. Equation 1' and 2 stress that exergy is a concept based on environment temperature. Equation 2 implies that exergy input minus exergy consumption equals exergy output.

Given that $T_{win} < T_{wout} < T_i < T_j < T_o$, energy flows are negative (Eq. 1') but exergy flows are positive (Eq. 2). Negative energy flows indicate that, for example, well water has a lower thermal energy content than the outdoor environment, and hence it has an ability to let the thermal energy in the environment flow into it. This also applies to the long-wave radiation emitted by the radiant panel and surrounding walls. Exergy flows are positive, but opposite in sign to energy flows; this implies a cooling ability, or 'cool exergy'.

5. RESULTS AND DISCUSSION

5.1 Indoor Thermal Environment

Figure 4 shows SET* [°C] time histories in the room equipped with the ceiling radiant panel, with and without outdoor sunshading on the south-facing window (black and gray line, respectively).



Outdoor air temperature was 27 ºC to 31 ºC and solar radiation at the horizontal plane was 400 W/m^2 to 700 W/m^2 for both cases.

Figure 4 SET* time history in the room, with and without outdoor sunshading

During the first hour of cooling system operation, SET* in the room was ca. 28.5 ºC, with and without sunshading. Thereafter, the effect of outdoor sunshading on SET* became more noticeable. In the case with outdoor sunshading (black line), SET* remained relatively constant until the cooling ceiling was turned off and the sunshading removed at 16:00 hours. In the case without shading (gray line), SET* gradually rose and reached 30.5 ºC at 16:00, in spite of the cooling provided by the ceiling radiant cooling system. These results show how the room indoor thermal environment benefits from outdoor sunshading.

The indoor thermal environment discussed in Fig. 4 was realized by means of supplying and consuming thermal exergy of well water and electricity at the ceiling radiant cooling system. In the following items, we show how the ceiling radiant cooling system consumed exergy from well water and electric power at each subsystem.

5.2 Exergy input, output, and consumption

5.2.1. Exergy flows with sunshading. Figure 5 shows exergy input, consumption, and output for the whole ceiling radiant cooling system, with sunshading. Exergy consumption [W] is shown in the rectangles for the subsystems radiant ceiling, three-way valve, circulation pump and well pump. The numbers shown beside the ▲ marks indicate the cool exergy content of the well water within the pipes. Blank arrows show cool exergy transfers associated with radiation (straight) and convection (curved). At the subsystem well, 435 W of electric power was supplied to the well water pump, and 398 W was consumed to draw well water from the bottom of the deep well. Well water pump exergy consumption was about 56 times lager than that of the ceiling radiant panel (=398/7).

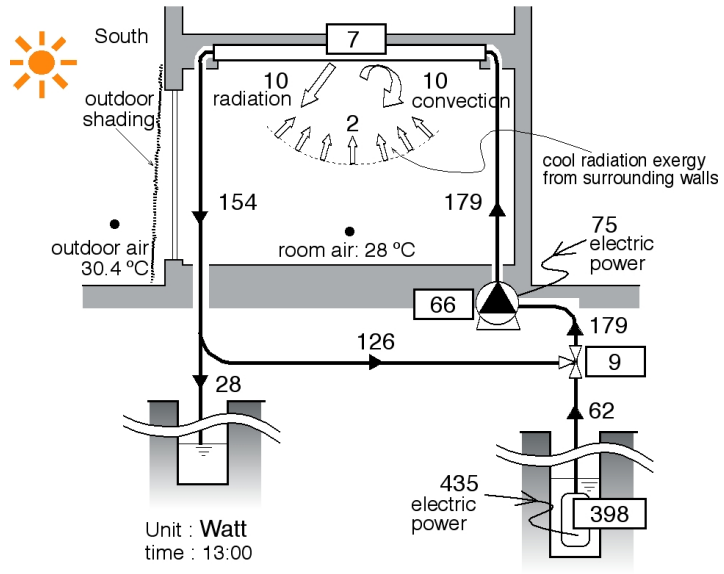


Figure 5 Exergy input, output, and consumption with outdoor shading

At the subsystem three-way valve, the cool thermal exergy input was 62 W (well water pumped up from the well) plus 126 W (return water from the ceiling radiant panel). The exergy output at this subsystem was the cool thermal exergy content of the mixed water coming out from the valve: 179 W. The difference, 9 W (=62+126-179) was consumed by mixing two water flows at different temperatures. This cool exergy of 179 W was the input to the radiant panel subsystem. 7 W of this cool exergy was consumed within the panel, 10 W were emitted as cool radiation exergy and another 10 W by convection. The radiant panel also received 2 W of cool radiation exergy emitted by surrounding walls and floor. These cool radiant exergy transfers also contributed to radiant cooling. The output from the radiant panel subsystem was the cool exergy content of the well water coming out of the radiant panel: 154 W (=179+2-7-10-10).

5.2.2. Exergy flows without sunshading. Figure 6 shows exergy input, consumption and output without sunshading. Exergy consumption at the subsystems well water pump and circulation pump was almost equal to the case with sunshading (Fig. 5).

Without outdoor sunshading on the South-facing window, the ceiling radiant panel subsystem consumed 13 W of cool exergy; this is about 1.8 times higher than the exergy consumption in the case with sunshading (Fig. 5). Not only did the radiant panel consume more exergy, but it also emitted less cool radiant exergy (8 W) compared to the case using outdoor shading (10 W). The cool radiation exergy emitted by the surrounding walls and

incident on the ceiling radiant panel surface was almost zero in the case without outdoor sunshading. These results show that, when outdoor shading was not used, the cool radiation exergy contribution for indoor radiation cooling was smaller, in spite of a higher exergy consumption of well water cool exergy at the ceiling radiant panel.

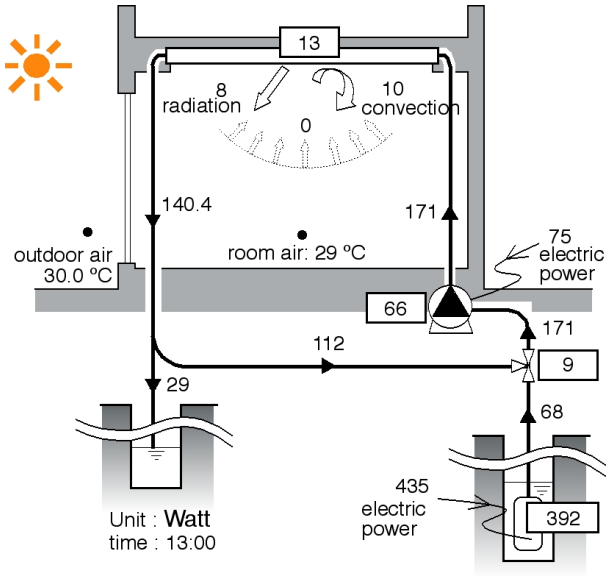


Figure 6 Exergy input, output, and consumption with no shading

6. CONCLUSIONS

We did measurements of interior thermal environment and electric power consumption in a house equipped with a ceiling radiant cooling system using well water, during the summer of 2001, and used exergy analysis to compare the use of well water 'coolness' and electric power within the system. The results showed the following:

1. The ceiling radiant cooling system consumed cool thermal exergy from well water and emitted a small part thereof as cool radiant exergy from the ceiling radiant panel surface; the system also consumed relatively large amounts of exergy as electricity at the pumps in order to transport water.
2. When outdoor shading was used, the surrounding walls and floor contributed to the radiant cooling effect by emitting cool radiation exergy. Also, the cool radiation exergy emitted by the ceiling radiant panel surface was increased, and the cool exergy consumption at the panel was reduced. Moreover, the use of outdoor sunshading improved the indoor thermal environment.
3. The well water pump consumed 30 to 56 times more exergy than the ceiling radiant panel, and ca. 6 times more than the circulation pump.

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1. INTRODUCTION

CSIRO is Australia's premier, largest and most diverse scientific research institution with a staff of approximately 6,500 working at some 65 laboratories and field station sites throughout Australia conducting research in 22 sectors of the Australian Economy, ranging from Pasture Crops to Mining Technology to Manufactured Products.

The CSIRO Energy Centre will provide state of the art research accommodation for staff of CSIRO's Division of Energy Technology on a 5-hectare site on an Eco-Industrial Park called "Steel River" at Newcastle, New South Wales, Australia. Now under construction, the research complex will demonstrate unique, leading edge, commercially practical examples of building energy demand reduction and environmentally conscious realistic energy supply options.

The Centre will provide a focal point in Australia for energy research excellence, particularly in the fields of:

- Sustainable energy, including energy storage and renewable energy;
- Environmental impacts of energy, particularly those associated with greenhouse gas emissions; and
- Cost competitive and environmentally acceptable fossil fuel research and development.

Key criteria in the design of the Centre included:

- Provision of energy efficient buildings with flexibility and adaptability for changing scientific research needs over the life of the buildings;
- Generation of energy on site from renewable and other sources; and
- Ability to match as closely as possible, the base buildings energy demand and the site generated energy.

A prime objective of the project is to accommodate CSIRO's energy research programs in a landmark facility that showcases what is possible in a contemporary Ecologically Sustainable Design (ESD) building and present CSIRO as a leader in this field. CSIRO's intent is for the facility to be the most energy efficient research complex of its type in Australia.

2. BUILDING DESCRIPTION

Stage 1 of the Centre will comprise buildings of approximately 9,800 square metres total floor area, consisting of three principal functional areas: Laboratories, Bay and Support Facilities, and Office/Support Facilities.

These main functional spaces have been arranged as three separate wings, 'plugged' onto a central circulation spine element, which will form the main circulation link for the complex. The spine will house main plant areas for the Centre, together with renewable energy plant and equipment such as photo voltaics, wind turbines and other future energy research elements such as fuel cells and battery systems. The integration of renewable energy systems will be a central feature of the Complex.

The laboratories and offices will each be housed in a separate wing on the east of the spine on a hillside which characterises 40% of the site. The process bays and associated facilities will be housed off the western side of the spine on the flat part of the site.

A site Masterplan provides for future expansion of the Centre by the addition of further process bays, office and laboratory wings. The Masterplan was developed from detailed analysis of various options for development of the site. In each option consideration was given to building image, views to and from the site, quality of internal working environment, relationship between office/laboratory elements and process bays, staff interaction, circulation, functionality, site access and egress, and suitability for incorporation of energy conservation and energy generation initiatives.

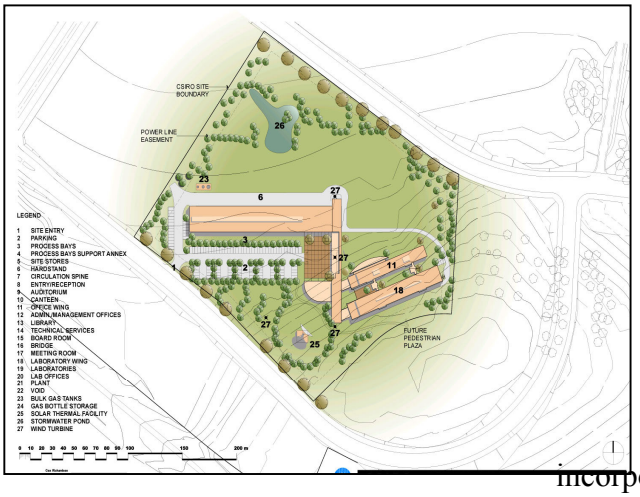




Figure 1 CSIRO Energy Centre - Stage 1

3. ENERGY RELATED INITIATIVES

3.1 Energy Optimisation

The unique Energy Centre development will incorporate and demonstrate leading edge, commercially practical examples of energy initiatives appropriate for modern buildings, particularly laboratory/scientific research facilities.

The initiatives being employed can be categorised in the areas of:

- Building energy demand reduction;
- Energy conservation;
- Energy generation;
- Energy management; and
- Ecologically sustainable development.

Objectives of the building energy optimisation process included:

- Establishment of a baseline energy model;
- Reduction of laboratory process loads;
- Reduction of building envelope impacts;
- Maximisation of natural climate opportunities;
- Reduction of internal equipment loads; and
- Optimisation of the building services design.

3.2 Building Energy Demand Reduction

Energy demand patterns were identified early in the design process for each type of space (laboratories, offices, process bays, etc) in the Centre. Base case designs were then determined for the building and process loads so that they could be compared with proposed designs, which included varying energy conservation initiatives.

Various studies were undertaken for possible energy demand reduction initiatives that included consideration of:

- The most effective building positioning in relation to site topography;
- Building siting to maximise use of natural light, including use of light shelves;
- Computer simulations of varying light conditions for daily and seasonal conditions, as part of the lighting and lighting controls design process;
- Individual staff comfort condition perceptions and requirements. The data resulting from a detail staff survey was used to develop a sophisticated, tailored system of internal climate conditions;
- Flexible use of base building services by individual users to achieve desired conditions (openable windows, low velocity air via an underfloor plenum); and
- Passive solar heating of thermal mass elements, especially in industrial function areas.

3.3 Energy Conservation

The options evaluation process for energy conservation initiatives comprised a series of simulations and modelling techniques in conjunction with the design of systems. Extensive building user consultation in the form of a questionnaire and workshops was also employed to ensure that strategies were developed that provided the most appropriate balance of user needs and energy use. While a key project goal was to achieve the most energy efficient building of its type in Australia, it was essential that it be balanced with appropriate functionality.

Conservation initiatives incorporated in the project include a wide range of both passive and active measures.

Passive measures, which are considered in the context of initiatives to reduce the impact of the building envelope include:

- Building orientation - maximum north/south exposure to maximise opportunity for solar control in summer and passive solar energy in winter;
- Elongated building envelope;
- Optimum building layout - maximisation of daylighting and minimisation of artificial lighting;
- Sunscreening to northern façade to control summer sun penetration and solar heat gains;
- Use of light shelves on north walls – to promote effective natural daylighting;
- Openable windows - to create opportunity for natural ventilation to office areas;
- Insulation of building fabric – to reduce heating and cooling loads;
- Window fenestration (Low E glass);
- Louvered windows to Process Bays;
- Minimal east and west facing windows;
- Thermal mass for heat retention and cold reduction; and
- Minimisation of infiltration.

Active measures include:

- Underfloor air conditioning system - features a low velocity plenum and consequent energy reduction (plus ability to accommodate services);
- Variable speed pumps and fans – to match system load fluctuations closely and minimise power requirements;
- Separate air handling plant for laboratory modules – provides for independent control and out-of-hours operation;
- Provision of economy cycles on all air handling plant
- Outside air economy cycle - to make full use of free cooling of outside air when appropriate;
- Variable volume air handling technology to allow reduction in supply of air to designated areas where appropriate;
- Choice of energy efficient chiller design, e.g. multiple step controls to match building load profiles, i.e. as load decreases, compressors are switched off to save energy;
- Low velocity air conditioning and mechanical ventilation duct systems in laboratories – saving fan power and minimizing energy consumption;
- Dedicated automatic lighting control system – time clock control, passive infra-red detectors, photo-electric controls;
- High performance fluorescent light tubing with low loss electronic ballasts;
- Power factor correction to transformer supplies – to improve building power factor and reduce energy usage and cost;
- Water saving devices on hydraulic fittings and fixtures – to minimise water consumption; and
- Building Management System to operate, control and monitor energy consumption for automatic control of mechanical services to provide efficient systems operation, alarm monitoring and implementation of energy management programs.





Figure 2 CSIRO Energy Centre – Cross Sectional View

Energy conservation measures also include the provision of building space heating energy from heat recovery from the renewable energy generation suite. It is expected that heat energy supplied in this manner will match the maximum possible heat load and consumption.

Domestic hot water will be supplied from heat recovered from the energy generation suite.

3.4 Energy Generation

The Energy Centre will incorporate an energy generation suite developed for both efficiency and the showcasing of available technologies.

An 'Energy Task Force' was instituted early in the design process to develop, analyse, evaluate, cost and recommend energy sourcing alternatives.

While output and efficiency of the systems, initial capital costs and payback periods were factors in the analysis of options, development of the energy generation suite was primarily based on an evaluation process and other criteria determined by the 'Energy Task Force' through a value management workshop process. The key evaluation criteria (not necessarily in priority order) were:

- Ability to minimise carbon emissions;
- Buildability - ability to integrate the technology into the buildings and the site;
- Deliverability - the degree of risk associated with availability of support;
- Commercialisation opportunity - ability to obtain support from the energy industry;
- Ability to accept future new technologies; and
- Image of CSIRO – positive public perception of the initiative.

The options evaluation process considered a number of main combined source options, all capable of delivering a power capacity of up to 500kW, estimated to be the average base building demand, excluding process loads. Several other options were initially eliminated from consideration for the following reasons:

- All single source options – one system does not reflect the agreed energy strategy;
- Two identified two-source options - insufficient spread of technology and risk;
- Options with a high dependence on photovoltaics - payback periods would be long term; and
- Options with a high dependence on wind energy - the wind energy resource at the site is sub-optimal (based on 5 years monitoring in adjacent area).

The selected energy generation suite comprises:

- Wind turbines - of both medium size with outputs ranging from 20kW to 100kW;
- Building integrated photovoltaic cell arrays - output approximately 90kW;

- Gas fired micro-turbines -capable of generating up to 150kW of electricity; and
- Future Fuel cells - fired by natural gas and water conversion to hydrogen, providing 100kW total output

The fuel cells and micro-turbines will be located within the central plant area and space has been allowed for the future addition of similar and/or more advanced technologies.

A CSIRO developed battery energy storage system capable of storing a maximum power level of 500 kW of site generated electricity, will be incorporated in the future to provide load levelling capability and an uninterruptible power supply backup.



Figure 3 Energy Generation Initiatives

The recovery of waste heat from energy generation will be used in the provision of domestic hot water and winter heating of office and laboratory spaces. This facility will eliminate the need to provide a boiler for these requirements.

3.5 Energy Management

Energy management at the Energy Centre will be structured at two levels and utilise two separate control mechanisms.

The management of energy generation will be provided by a dedicated System Control and Data Acquisition (SCADA) facility, which will report on energy quality and quantity and its distribution. The system will comprise monitoring and control points for plant elements or group of plant elements in one area of the site communicating to a single control centre. (For example; it will be possible for generation output from individual elements, such as one wind turbine, to be displayed on a continuous basis and/or as required. Energy audits will be available from the facility to monitor actual performance for comparison with design target).

The buildings will be grid-connected such that in periods of high demand, electricity will be imported from the grid to supplement site-generated energy but in periods of low demand site-generated energy will be exported to the grid

Management of energy efficiency/conservation initiatives will be provided by the Building Management System, which will monitor and/or control all building engineering services throughout the complex. The system will cover plant and equipment, air flows, filter performance, fume and other exhaust systems, heating and chilled water, steam, vacuum and gases reticulation, constant temperature rooms and artificial lighting. The system will also be programmable with graphics interfaces for full zone control, will incorporate facilities for external monitoring and will be capable of expansion.

Energy audits will also be available from this system to monitor the energy performance of the Centre.

3.6 Ecologically Sustainable Design Initiatives

From the purely buildings design perspective, ecologically sustainable design is the overriding consideration in the development of the Energy Centre. It incorporates all of the elements outlined and requires that all such elements form an integral part of the design and not appear to be ‘add-ons’. The ESD initiatives can be summarised as follows:

3.6.1 Building Energy Demand Reduction

A responsible and well-structured approach to the consideration of energy demand reduction in the Centre’s development process, has demonstrated that significant results can be achieved.

3.6.2 Building Energy Supply

While the Energy Centre’s energy needs could be supplied by connection to the statewide electricity and gas grids, emerging energy efficient and renewable technologies have been incorporated into the building’s design to the maximum reasonable extent. This approach

reflects a corporate recognition and acceptance by CSIRO that the long-term view must be taken as part of both a national and international responsibility.

Accordingly, the CSIRO Energy Centre will be both a demonstration of these technologies to a wider audience as well as an ongoing platform for further development as part of the energy research programs of the Division.

3.6.3 Building Energy Storage

Provision has been made for the future storage of between 500 kWh and 1000kWh of power
(equivalent to 100% of the Centre's estimated bas buildings requirements). This will provide for the most cost-effective controlled use of power that is generated in off-peak times and/or in excess of demand. This facility will enable the demonstration of the interaction between energy supply and energy storage systems.

3.6.4 Environmental initiatives

The environmental initiatives planned for incorporation in the Centre cover all aspects of the energy design, buildings design and systems development process. They include for example, passive design considerations, active building service elements and comfort conditions awareness.

These considerations translate into building inclusions such as:

- Rainwater collection and retention tank storage with a pumping system to provide water for irrigation;
- Air quality monitoring particularly for carbon dioxide. The provision of sensors in return air ducts in the offices will be used to monitor indoor air quality;
- Photovoltaic cell arrays will be located to avoid overshadowing from buildings;
- The site energy generation system will be controlled by a System Control and Data Acquisition (SCADA) facility and accordingly all elements of the plant will be linked to a central computer system which will enable selective public display of energy generation from wind turbines and photovoltaics;
- Heat recovery form site energy generation to provide for heating and some domestic water requirements;
- Waste treatment systems;
- Water saving devices on hydraulic fittings and fixtures; and
- Sustainable use of site indigenous native vegetation.

4. ENERGY SAVING OUTCOMES

The result of building energy demand reduction initiatives will be a base building energy demand load estimated from Energy Simulation studies to be **less than 60%** of the energy demand for a comparable modern, conventional building to serve a similar function.

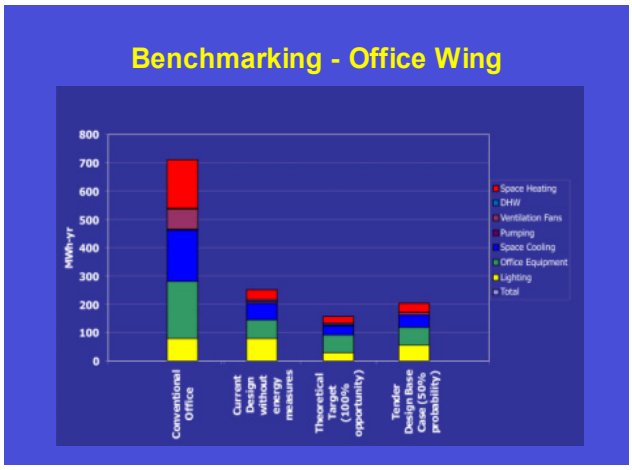
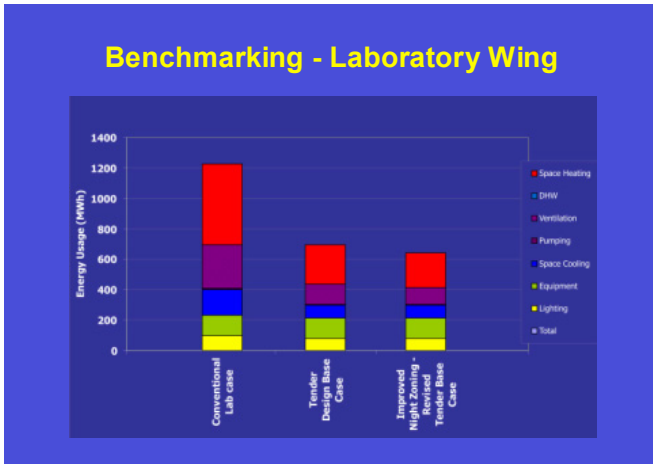


Figure 4 Energy Simulation Studies Outcomes

It is predicted that the greenhouse gas emissions savings from the Project will be up to 2000 tonnes of carbon dioxide per year compared with a modern similar research facility.



5. CONCLUSION

The achievement of the expected energy saving outcomes in practice will establish the Energy Centre as a tangible and unique expression of commercially practical examples of building energy demand reduction and environmentally conscious, realistic energy supply options.

The expected level of performance of the Centre will be a valuable national example of the possibilities that sensible and responsible building design can produce.

It will be clear and unarguable through the development of the Centre that buildings and energy systems design can contribute to national greenhouse and ESD commitments and obligations.

Construction and Demolition Waste, its Variability and Recycling in Brazil

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1 CDW GENERATION RATE IN BRAZIL

There are few consistent studies on construction and demolition waste (CDW) generation rates in Brazil. However, the available data does allow suggesting that the amount of CDW is probably higher than the amount (w/w) of Municipal Solid Waste (MSW). A typical Brazilian per capita CDW generation rate for some cities is above 500 kg/year (Table 1).

Table 1 CDW Quantity, population and some generation rates in Brazil (Pinto, 1999).

City	State	Population (Inhab.)	CDW Quantity (ton/year)	CDW per capita (kg/year)	Data from year
Santo André	São Paulo	625,564	369,745	591	1997
Vitória da Conquista	Bahia	242,155	113,150	467	1998
Ribeirão Preto	São Paulo	456,252	380,695	834	1995
São José do Rio Preto	São Paulo	323,627	250,755	775	1997

These values are consistent with reported international generation rates. The reported CDW participation in the total MSW varies from 13% (Bossink; Brouwers, 1996) to 67% (Lauritzen, 1994). A study conducted by the European Union reports a variation of the per capita generation from 136 kg/year up to 3359 kg/year (EU, 1999). A significant portion of the variation in CDW generation rates is a direct result of CDW definition. Other sources of variation are the differences in the industrial structure and the degree of development as well as the characteristics of the building technologies used in each country, etc.

2 ORIGIN OF CDW

Like most developing countries, Brazil is still under construction. The construction related business is about 15% of the Brazilian GNP. Because of the relatively high production of construction waste at building sites, CW represents approximately 50% of the total CDW generated (Pinto, 1999). In more developed countries, like those of Europe and the USA, the construction activity is responsible for about 1/3 of the total CDW produced (Lauritzen, 1994; Peng *et al,* 1997*)*

In Brazil, construction waste quantities are increased due to high rates of material wastage at building sites. Table 2 presents selected wastage rates measured at about 63 new building sites in Brazil (Souza *et al.*, 1999). This data is valid only for the formal construction industry. Until now, there has been no data about material wastage for the informal (do-it-yourself) construction sector, which produces most of the low-cost houses in Brazil.

Table 2 Material wastage in new building sites and estimations of construction waste (Souza *et al*, 1999; Andrade, 2001).

Materials	Wastage (%)			Waste (%)
	Median	Minimum	Maximum	2.1.1 Median
Concrete	9	2	23	1.3
Steel	11	4	16	7.7
Blocks and bricks	13	3	48	13
Ceramic tiles	13	5	19	13
Mortar (screed)	42	8	288	2.1

3 CDW TRADITIONAL MANAGEMENT IN BRAZIL

As a rule, municipal policy towards CDW residues has been to ignore them. The only strategy towards CDW traditionally adopted by local authorities has been to repeatedly clean fly tipping areas and, sometimes, operate a CDW landfill or accept CDW dumping in the municipal solid waste landfill. Nevertheless, the landfill never succeeds in attracting more than a fraction of the total CDW generated and fly tipping is the most common private solution adopted for disposing of CDW. The landfill operated by the city of São Paulo attracts only 15% of the total CDW generated in that area (Schneider, 2002).

Fly tipping areas can be streets (Figure 1), parks, private areas and creek banks. The environmental impact associated with this kind of dumping is important. The proliferation of pests (rats and poisonous insects, among others), traffic hazards and landscape destruction are part of this issue. The city of São Paulo estimates that illegal dumping in public areas is as high as 20% of the total CDW (Schneider, 2002).

Removing this illegally dumped CDW is also very expensive. In city of São Paulo, the local authorities report spending about R$45 million a year (about US $19 million) removing illegally dumped CDW (Schneider, 2002) from the “one” official CDW landfill.



(a) (b)

Figure 1 Illegal dumping sites in city of São Paulo. (a) Street used as dumping area just after being cleaned by the local authorities (2002-08-30) (b) the same area after two months (2002-11-04).

Most middle-sized and big cities do have private CDW landfills. Most of these landfills operate without a license. Environmental licensing is very difficult because there are no consolidated regulations. Also, private dumping sites do not have any design that ensures stability and there is no practical control over the waste dumped, leading to great risk of environmental contamination. It is known that one illegal C&D landfill collapsed about 10 years ago in São Paulo, killing 13 persons.

As a consequence, CDW management is a profitable business, with revenues estimated to be higher than US $40 million/year in the city of São Paulo alone (John; Agopyan, 2000). Most CDW in Brazilian middle-sized and big cities is collected and transported by specialized private companies, using open containers (chain lift skips).

In big cities like São Paulo, there are no longer so many places suited to be landfills. So the landfill prices are increasing. Also a significant part of the CDW generated in São Paulo is, at present, being "exported" to other municipalities within the metropolitan area and illegally dumped there. This additional distance adds to the cost of transport and disposal. The price for removing and dumping a $4m^3$ container (including the renting fee for up to a week) can be as high as US $30,00[1] in São Paulo.

There are some companies that recycle CDW as rendering mortar using a small rotating mill installed at the building site (Miranda, 2000). Grigoli (2000) reports other uses of CDW in-site.

4 TRENDS ON CDW MANAGEMENT IN BRAZIL

Management of CDW is changing very fast. In the next few years most municipalities are expected to develop specific policies towards CDW.

Some municipalities, such as Belo Horizonte, have already implemented successful systems to manage CDW and others are in the process of doing the same. This system includes registration of companies that transport CDW, a well-located network of CDW deposit sites which attract most of the CDW and a recycling plant, which produces aggregates and gives proper destination to the metallic and organic fraction. Education is an important component of the system as well as an effective structure to prevent and punish fly tipping. In big cities, like São Paulo, stations sort the waste and transfer it to bigger trucks, making the system cheaper and reducing the impact of transporting the CDW in urban area.

The CDW recycling plant belongs to the municipality, which consumes most of the aggregates as road base. Very frequently, political changes halt the entire system. São Paulo, Londrina and São José dos Campos are examples.

The National Council for the Environment (CONAMA) is in the process of approving a directive on CDW management that will require all municipalities and building contractors to set up management schemes. This directive has been negotiated with the community. Additionally, the CDW Task Group of the Environmental Chamber of the Construction

[1] Exchange rate US $1 = R$2.4

Industry of the State of São Paulo is drafting drafts of technical standards related to the use of recycled aggregates as well as proposals of regulations for licensing CDW landfills and transfer stations.

As a result of these efforts, recycling construction demolition waste is expected to become an important business in Brazil in the near future.

5 RECYCLING PLANTS TECHNOLOGY

Brazilian CDW recycling plants are simple and stationary. As in Europe, most of plants are derived from mining engineering but do not apply any better technological equipment or new ways of more elaborate separation and concentration (Hendriks, 2000). As a rule, these plants consist only of manual pre-sorting system, crushers, manual sorting that removes contamination, conveyor belts and screenings (Figure 2). A magnetic separator is used in some plants such as the ones in São Paulo and Belo Horizonte. There is no systematic control of the arriving material although there is visual inspection. Likewise, there is no systematic quality control of the delivered aggregates.



Figure 2 Typical Brazilian CDW recycling plant (City Municipality Vinhedo – São Paulo state) aggregates for road base.

Most of the aggregates produced by the recycling plants are used as road base in urban paving activities. Some tentative applications of selected recycled aggregates for concrete component production (concrete blocks and paving blocks) have been made, in the cities of Vinhedo, Belo Horizonte and Santo André. However, in at least one case, the cement consumption rate was at least 30% higher that the required for natural aggregates.

6 CDW, ITS VARIABILITY AND RECYCLING POSSIBILITIES

6.1 Sources of composition variability

CDW is a mixture of the materials used in the building (Figure 3 and Figure 4) and the composition is highly variable. In Brazil, the typical building waste is a mixture of ceramic or concrete blocks, mortar, reinforced concrete, steel, plastic, asbestos cement and wood. The use of gypsum as plasterboard or plaster is on the rise and is expected to become a significant part of the waste in a few years' time.



Figure 3 Contamination of a CDW container in downtown São Paulo, by litter. In addition to the litter, there is mixture of waste from masonry, concrete, wood and rubber.

Construction waste, which is about 50% of the Brazilian CDW, is considered to be more mixed and variable because there is less discipline in waste discharge. This is due to the wide variety of contractors, the high cost of waste separation, insufficient areas for waste discharge and different waste period production in building sites (Hendriks, 2000). In Brazil, demolition waste also tends to be a mixture of all phases, because sophisticated selective demolition techniques are only applied to very old residential buildings, where the bricks, windows, etc have a high market value.

As most of the CDW containers are parked in the streets or in front of the building site, neighbours often place additional litter in the containers, further increasing the contamination (Figure 3).
So, without changes in CDW management at both construction and demolition sites, it will be very difficult to classify the arriving waste as predominantly concrete or masonry, as specified by European countries (Rilem Recommendation, 1994; Hendriks, 2000).



Figure 4 Brazilian CDW in containers typically contains a mixture of masonry, mortar and concrete.

6.2 Composition variability

As can be seen in Table 3, the composition of Brazilian CDW recycled aggregates is highly variable. Angulo (2000) presents results of the most comprehensive investigation about the variability and quality of CDW aggregate produced in Brazil. While studying the operation of an experimental recycling plant in Santo Andre (São Paulo Metropolitan Area), the author took hourly samples during 12 working days. Zordan (1997) results are after three random samples.

Table 3 Reported composition and its variability for some Brazilian CDW aggregate recycling plants.

Composition (%)	**Angulo (2000)**			**Brito (1999)**	**Carneiro *et al.* (2001)**	**Zordan (1997)**		
	Min	**Av**	**Max**			**Min**	**Av**	**Max**
Concrete	23	44	62	32	53	20	21	22
Gravel	3	23	50			10	19	28
Mortar	10	28	61			35	37	39
Ceramic	0	4	13	33	15	16	23	30
Soils	-	-	-	30	21	-	-	-
Wood & Organic	-	-	-	1	4	-	-	-
Others	0.0	1.2	4.6	4	7	-	-	-
City	**Santo André**			**São Paulo**	**Salvador**	**Ribeirão Preto**		

6.3 Variability and recycling

The high variability of the composition is in itself a major problem when recycling, even when considering its use as road base aggregate.

Angulo and John (2002) compared the aggregates' characteristics (mortar + ceramic maximum content, maximum water absorption, density, maximum content of contaminants and filler content) with those specified in the RILEM recommendations and the Dutch Standard (Rilem Recommendation, 1994; Hendriks, 2000). None of the 36 samples studied complied with the standards for use in structural concrete. And only 10 samples did comply with the Dutch rules for demolished masonry aggregate, suitable for use in non-structural concrete applications. The major reasons for non-compliance with non-structural applications were filler content and the presence of contaminants as well as mortar plus ceramic maximum content. The contaminants most frequently detected were asphalt, glass and wood. No evaluation for sulphate control was made.

Zordan (1997) investigated the effect of the variation of the composition of the CDW in concrete. It was found that compressive strength is reduced 30% for 1:3 (cement/aggregates proportion) and w/c (water/cement) relation of 0.5 when the composition varies (see Table 3).

Miranda (2000) studied the influence of CDW composition variability on performance rendering mortar. Laboratory produced waste was analysed to determine what influence the content of concrete blocks, ceramic blocks and mortars have in the properties of fresh and hardened mortar samples. An increase in mortar content generated a higher incidence of cracking on rendering caused by higher water/cement relation.

So, at present, road base aggregate seems to be the only market for recycled CDW aggregates. However, in most cities, the municipal consumption of road base aggregate is not enough to consume the total available waste (Pinto, 1999).

Consequently, long-term development of a market big enough to recycle all CDW will demand new and more valuable applications. To achieve this goal it will be necessary to (a) introduce changes in CDW management for construction, demolition and transportation, (b) to significantly improve the recycling plants.

6.4 Improving Brazilian recycling plants

One possibility for improving CDW recycling plants is the adoption of equipment to classify the waste based on its specific gravity, like jig (Jungmann; Quindt, 1999; Ancia *et al.*, 1999). This kind of technology allows separating the densest aggregates that can be, potentially, recycled in more valuable applications, like concrete production. Results from Angulo (2000) confirm that this technology can be very useful in the Brazilian market (Figure 5).

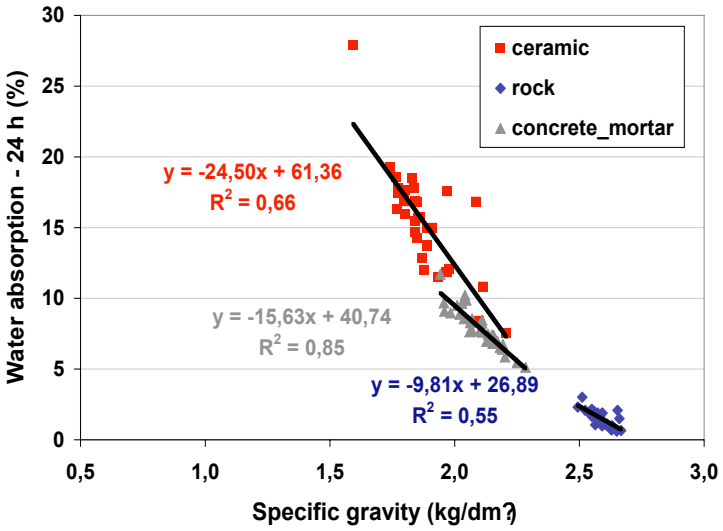

Figure 5 Water absorption x specific gravity of different CDW aggregate phases (Angulo, 2000)

Another option is the adoption of homogenisation piles, especially when combined with jigs, because they drastically reduce the variability of composition, density and water absorption. Simulations with the data from Angulo *et al* (2001) show that piles , which were accumulated during 3 or more weeks of production presented stable compositions, water absorption and specific gravity. Considering the typical production of a recycling plant to be above 300 ton/day, the homogenisation pile would require a relatively large storage area, which would reduce the recycling site options and increase the site cost. Combining the homogenisation technique with jig classification can reduce the time necessary to get a stable composition

Developing a fast and cheap methodology to control the quality of recycled aggregates is also vital to the development of more sophisticated markets for the aggregates. Such techniques must be precise enough to allow certification of the composition and other quality relevant requirements of the generated aggregate.

7 CONCLUSIONS

C&D Waste is a relevant problem in Brazilian society. The generation rate is high, being around 500 kg/year *per capita*. Illegal dumping is a current practice, with considerable social and environmental impact. Nevertheless, CDW management is a prosperous business in most cities.

At present, the amount of recycled waste is very small and the resulting product is used as road base. The technology of the recycling plants is very simple. There is no systematic quality control of the resulting product. It results in aggregates with high variable compositions and with a high content of ceramic and mortar materials. A small fraction of the resulting aggregate is suitable for more valuable applications like producing concrete and concrete components.

The ongoing changes within the institutional framework, especially the national regulation on CDW, technical standards and the development of municipal policies will greatly increase the demand for recycling in the near future.

In order to increase recyclability and attract private investments to the recycling market, both waste management practices and recycling technology must be improved. Homogenisation piles combined with density based classification systems (jig) are interesting options for the technical improvement of recycling plants.

8 ACKNOWLEDGEMENTS

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Sustainably produced hot-rolled sections in sustainable buildings

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1. INTRODUCTION

The construction industry bears considerable responsibility for implementing the principles of sustainable development in the man-made environment.

Within this presentation, sustainability aspects of hot rolled steel sections will be addressed in detail. Steel beams, the world's most recycled products, not only allow to design sustainable buildings but also suit aesthetic criteria and provide speed of implementation, flexibility, lightness as well as safety.

Before recycling, buildings with steel structures can be readily designed to facilitate reuse or dismantling and reconstruction at the end of their useful lives. As an example, the extension project of the new Luxembourg Chamber of Commerce has given the ecologically-responsive architect and designer the opportunity for achieving a sustainable construction by incorporating steel framed structures in the building environment. Also, the stripping down to its bare structure and the subsequent renovation of the original Chamber of Commerce building has demonstrated the flexibility and adaptability of steel structures for retrofitting.

2. ENVIRONMENTALLY-FRIENDLY PRODUCED OF HOT ROLLED SECTIONS

Nowadays, most Western European producers of hot rolled structural sections are committed to sustainable development and to continuously improving their environmental performance. Focused on the production of long products like beams, merchant bars, piling sections, rebars and special sections, the world's largest manufacturer ProfilARBED extensively renewed its production facilities in the mid to late 90s. The integrated steel mills, using the limited resources of local iron ore, were converted to the electric arc furnace (EAF) route, based on recycled ferrous scrap as sole raw material (Figure 1). The determination in maintaining and improving the high level of quality of its long products while simultaneously satisfying the toughest environmental requirements led to the use of the best available technology in its production facilities.

3. PRODUCING STEEL BEAMS FROM SCRAP

The new mills all operate according to the following process route:

- collection of raw materials,
- scrap-based electric arc furnace steel-making,
- continuous casting of near net shapes (beam blanks),
- rolling sections to final shape.

3.1 Collection of raw materials

The major part of the raw materials used for the steel production process consists of disused steel products, ranging from radiators, furnishings, and car bodies to sections from dismantled buildings and structures. Painted and zinc-coated scrap can also be processed. The scrap originates within a radius of a few hundred kilometres from the production plants. It is brought by barge, by train and, to a lesser extent, by truck. Each single load of scrap is checked for radioactivity before being processed, thus avoiding the possible contamination of the production installations and ensuring the production of clean, non-hazardous hot rolled sections.

3.2 Scrap-based electric arc furnace steel making

The technology for melting scrap in state-of-the-art electric arc furnaces considerably enhances productivity and reduces all types of emissions. The modern electric arc furnaces (Figure 2) are highly automated and computer-controlled. They are equipped with oxygen and carbon injection lances for slag foaming and high power sidewall burners to assist the melting process. The final steel grade is adjusted in an intermediary electric ladle furnace by adding small amounts of alloying elements.

Also, the modern electric arc furnaces are designed to guarantee a high degree of environmental protection and optimal working conditions. The furnace halls are completely enclosed and soundproofed; all emissions are filtered in a high performance bag house. The primary waste gas is cleaned by a complete combustion followed by quick cooling, and collected dust is recycled in the non-ferrous industry to recover zinc. The minimal quantity of slag, produced within the EAF route, is used as a high quality aggregate for road surfacing.

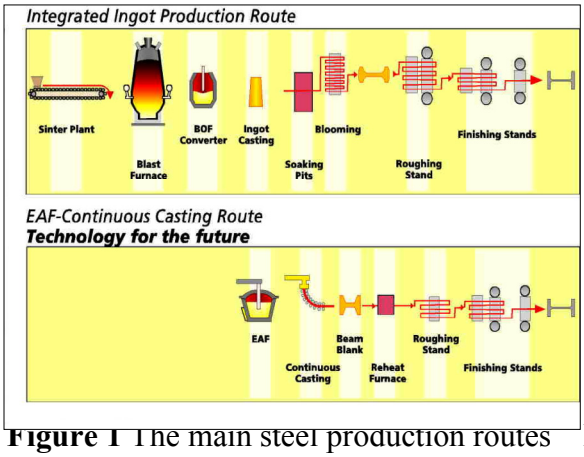


Figure 1 The main steel production routes

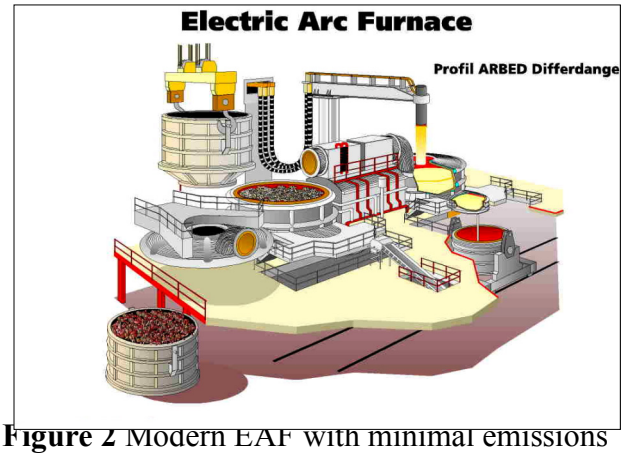


Figure 2 Modern EAF with minimal emissions

3.3 Continuous casting of near net shapes

Typically, the modern plants are equipped with state-of-the-art near net shape casters. For the efficient production of beams, the continuously cast semi-products are H-shaped beam blanks (Figure 3). All structural steels, including top quality offshore grades, can be produced via EAF and beam blank continuous casting. Thanks to this technology, additional energy savings are achieved in the rolling process.

3.4 Rolling of the section to final shape

The careful design of the beam blank shapes and the roll pass schemes results in a considerably simplified rolling process, thus combining high productivity with substantial energy savings in modern rolling mills (Figure 4). Moreover, sections rolled from beam blanks show excellent surface quality and internal soundness as well as good mechanical properties.

The recent development of the Quenching and Self-Tempering (QST) process allows the production of high strength beams in HISTAR grades with outstanding mechanical and technological properties. This in-line heat treatment operates without external supply of energy and substantially limits the use of alloying elements in the steel. In fact, the QST process allows to further up-cycle steel scrap as the constructional performance of a beam in HISTAR steel grade is by far superior to the performance of a standard beam.



Figure 3 Near net shape cast beam blanks

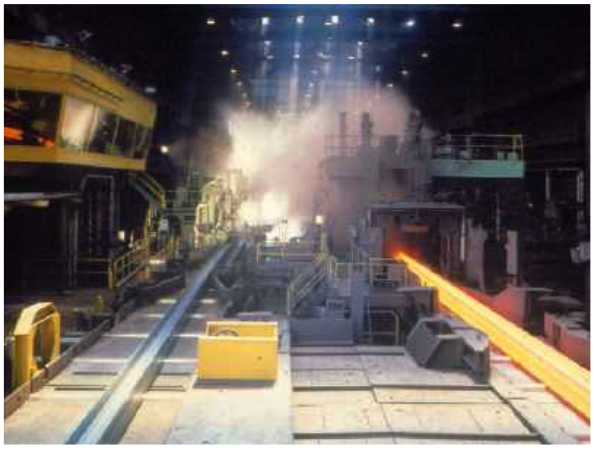


Figure 4 State-of-the-art rolling mill

4. THE WORK TOWARDS THE PROTECTION OF THE ENVIRONMENT

Traditional steel production was generally associated with emissions of dust and waste gas, and high energy consumption. The introduction of the EAF route has dramatically changed this situation. Taking both the emissions and the primary energy input of the new installations into account, their environmental benefits are clearly demonstrated in Figure 5. In Luxembourg, the recent launch of a highly efficient combined cycle energy plant, located in the vicinity of the steel plants, allows for a further reduction of primary energy use.

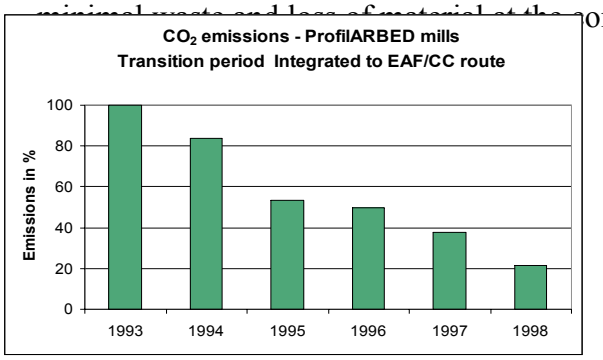
Within the different steps of the steel making process, water is needed for cooling. As it circulates in a closed loop, the water consumption of these new melt shops is small and does not constitute a significant environmental issue.

Another advantage of producing hot rolled sections from scrap is that less than 50% of the original terrain surface area is needed to manufacture the same quantity of hot rolled sections. The land freed by this process is thus available for urban development. With respect to Europe's industrial heritage, some of the original production facilities like the blast furnace installations are preserved as historical monuments.

5. HOT-ROLLED STEEL SECTIONS FOR SUSTAINABLE CONSTRUCTION

The shapes of hot rolled structural sections are mostly standardised and produced with minimal tolerances. In perfect harmony with the requirements of architects and contractors, these sections feature the following advantages:

- they can be processed by local steel fabricators for the construction of multi-storey and industrial buildings, bridges, etc. ,
- they enable a high degree of prefabrication, facilitating fast and clean erection with minimal waste and loss of material at the construction site



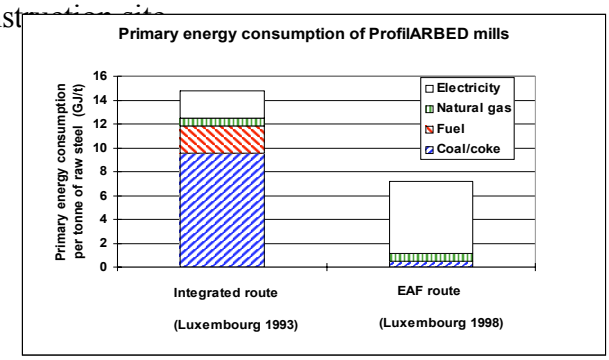


Figure 5 CO_2 emissions (left),primary energy consumption (right) at Luxembourg steel mills

- the use of prefabricated building elements in steel structures substantially enhances the construction speed,
- prefabricated steel elements allow for easy dismantling and re-erection of the structure once the building no longer meets construction requirements. Reintegrating the steel elements into other structures is also an option. In case the steel elements no longer fulfil a useful part in a structure, they are recycled as scrap.

The development of high performance structural steels with yield strengths up to 460N/mm^2, such as the HISTAR grades, enables the building industry to:

- reduce its overall steel consumption,
- reduce the impact of transportation of materials due to lower weight,
- design slender load carrying elements occupying less space in a building,
- design bold and outstanding structures.

Nowadays, improvements in the development of protective coatings, fire-resistant insulation materials and new design methods based on the Natural Fire Safety Concept allow a realistic and economical design of steel structures, thus minimising the environmental impact of the resources used.

5.1 Energy input in sustainable buildings

Hot rolled beams satisfy the demands of the 21st century. They comply with environmental standards, suit aesthetic criteria, and allow speed of implementation, flexibility, lightness and safety. Steel is more than a product; it is a concept that meets the requirements of both people and environment. The ecological development in building construction incorporates the building environment as well as innovative systems for optimising the building services. Performance can be established by the Life Cycle Assessment, which monitors:

- the embodied energy of the structural system,
- the embodied energy of the secondary construction materials,
- the energy used for climate control based on a mechanical Supply & Extract service system.

Typically, the embodied energy of the considered steel structures is very small when compared to total energy consumption of a building over its whole lifetime. The following conclusions are significant when selecting the materials for a low-energy, multi-storey building:

- there is no operational energy benefit in the passive thermal performance of conventional office buildings compared to modern steel-framed buildings. Massive structures are not required to exploit the benefits of energy storage in office buildings,
- the relative values of embodied energy as compared to operational energy have been assessed showing that, on average, maintenance and use are responsible for about 75% of environmental impact throughout a building's service life. The embodied energy of the building structure itself (steel frame + concrete floors) represents typically ~6%.

5.2 Flexibility and adaptability

Well-designed steel frame buildings are extremely versatile and can be easily altered to suit other functions and activities. One example out of many is represented by the 5 storey building of the Luxembourg Chamber of Commerce, which has been stripped down to the bare structure before being renovated in the frame of a large extension project (Figure 6, Figure 7).

Thanks to their low weight and adaptability, steel structures are usually chosen for the renovation of old buildings. Supporting frames are easily adjusted within the original façades or extra floors are added.



Figure 6 Luxembourg Chamber of Commerce in 2001 (left); stripped for renovation (right)

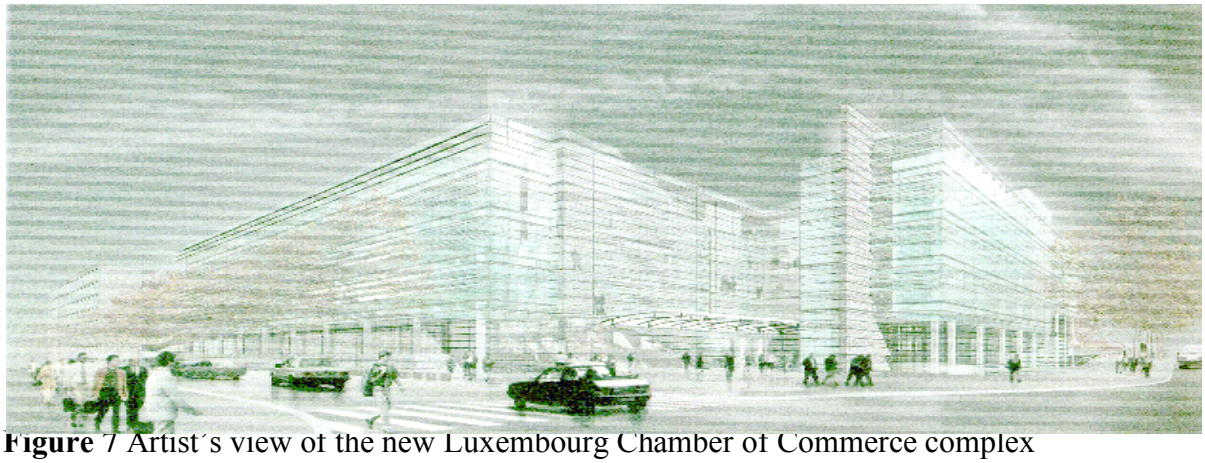


Figure 7 Artist´s view of the new Luxembourg Chamber of Commerce complex

5.3 Health

Iron is required daily by the human body. Likewise, steel is not a health hazard. It does not emit volatile, hazardous or allergenic substances, which further enhances its suitability as a construction material. Also, structural steel has no own electric or magnetic field. The influence of steel beams on electromagnetic fields within buildings is insignificant with respect to any harmful biological effects on human beings and animals. Opting for a steel load-bearing structure is the first step for sustainable construction. Steel framed buildings achieve good thermal isolation as well as heat storing capacity, thus providing optimal working and living conditions for their occupants.

5.4 Closing the loop

Once steel framed buildings no longer fulfil a useful purpose at their original location, they can be dismantled and their structure reused either as a whole or as individual components. It is indeed beneficial for the environment to preserve the value added by manufacturing the steel sections.

Steel-framed car parks for instance have demonstrated their usefulness as temporary structures. At the German airport Munich-Riem, some of the existing multi-storey car parks were no longer required when the airport went out of operation. One structure was dismantled and split to be rebuilt in two halves in Cologne and in Essen. Other examples can be found in all European metropolitan areas. They cover different building types, ranging from residential buildings to schools, exhibition halls and churches.

Once the steel components no longer fulfil a useful purpose, they can easily be scrapped and recycled.

6. SUMMARY

Sustainable Development is defined in the Brundtland Report as 'a development that meets the needs of the present without compromising the ability of future generations to meet their own needs.' The new electric arc furnace route allows to fulfil the requirements of this principle as the whole range of structural sections is produced from indefinitely recyclable scrap. Also, the concept of sustainable development involves all the decision-making players in the environmental policy, which ensures that main attention is paid to the environmental issues.

The hot rolled steel sections are produced from the world's most recycled material and thus contribute to a sustainable society. Their use in construction limits the usual nuisances caused by building sites, where reduction of emissions such as noise and dust as well as smaller working areas involved help to restore a favourable environmental balance. The long-life steel sections satisfy the demands of the 21st century: they allow for optimised material strategies in steel-framed structures such as reduction of material input, prefabrication, reuse or reintegration of the sections, and finally of recycling.

Studies on the life cycle assessment of office buildings demonstrate that there is no significant difference between the environmental performance in terms of the embodied and operational energy of steel framed buildings compared to similar buildings framed with other materials. In addition, human beings, animals and vegetation are not affected when exposed to steel.

Using the steel sections from the EAF route enables architects and designers to swiftly construct safe, long-lasting and aesthetic buildings at competitive prices. The fact is highlighted that steel construction is also an ecological responsible choice, enabling the decision makers in the building industry to be fully in line with the principles of Sustainable Development.

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The Thermal Comfort Management and the Transfer of Knowledge by Means of Tools and Intelligent Environments

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RÉSUMÉ ABSTRACT
Knowledge transfer in the field of architecture, can be done while making simulation tools available in the building design professions.We try, by an approach of design process analysis, to identify the various facets of the act of construction (building) and the barriers encountered in the use of the thermal simulation tool and the practice as regards simulation
The problem of the existence of barriers was the subject of several studies, including several research organizations, consultants and workshops in the schools of architecture.
The issued observations and remarks are used as the basis for several tests, resulting in recommendations and the creation of an integrated and modular environment (administrative of the project) containing methods of control which take into account all the aspects of design ,from energy decision-making to the use of the simulation tool.
On the basis of this report, we will try to define the integrated environment (Project Manager) and which is founded on the interface between the expert (the user, modelled fundamental data, knowledge) and the machine.

INTRODUCTION.
In the field of architectural design, several elements of conceptual nature (artistic and scientific) are handled at the same time; these elements are treated and called for in the form of interactions in order to arrive at the final solution of the project. [1]The architectural and environmental design conception desires to be and defines itself as a very complex act which requires "the transformation of an initial body of insufficient information, into a final body making it possible to communicate the shapes and dimensions of the building, to a building site" [ ]
The traditional engineering building tools are not used in the same way by an architect, an environmental engineer and a technical engineer (of application), even if their goals are identical, their steps are different.

In the following , we have evolved into stages which explain to us the instrumentation of the project and the supervision of the project by the project superintendent.
In the current context, we notice that there are very few professional tools which can really be in reach of the architect in the upstream phase of design
He is seen having to call upon other competences, energetician, heat engineer, monitor of environment etc., in order to answer all the requirements of the project and competition..

This gap is caused by the bad evaluation of the steps of construction on behalf of the specialists and the editors of the design assistance tool, and by the incomprehension of the approach to the resolution of the problem in architecture.
This situation encouraged the community of researchers [2] to analyze closely the work and the process of the architect while thinking in total terms of the design, from taking stock of the site and of the weather data to the treatment of the walls in terms of color and physical behavior, while trying to develop environments which answer the context of the work of architect
Because the work of the architect has form of resolution parallel to the encountered problems, it is necessary to try make available interactive tools, by offering to him a pallet of tools for simulation
The latter will be constrained by integration in the project phase, and the objective is to answer the various requirements of the designer, while being convivial.
In the case of the project, the question posed is the following one: "how to formalize technical knowledge, in the case of the energetic of the building, to integrate it in CAD tools for the architect"? [3]. In the current context, one can add the environmental problems to the energy problems.

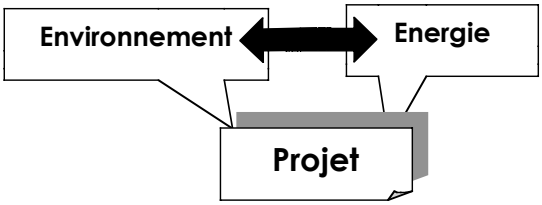


Figure 1:interaction between Energy, Environment and Project

LES DIFÉRENTES SPÉCIALISATIONS ET CONNAISSANCES.
Various specializations in the building trade require more agents and intervention, direct or indirect. This gave way to a division of roles between architects, heat engineers, acoustics experts decorators, environmentalists, landscape designers, etc. Rules of play were laid down in this context; for example, the heat engineer gives missions of assistance and council to the architect, while intervening in particular in the preparatory project phase of (in calculations related to regulation up to design).
The interventions of the thermal engineer can thus call into question the decisions or the choices made by the architect, which gives way sometimes to a delicate dialogue, going, until a professional "crash" occurs.
The architect sees his building in a different way from that from the heat engineer or the lighting engineer; he reasons in terms of space, opening, light and environment, while the heat engineer analyzes the building from the angle of energetics (thermal zones, thermal regulation RT2000, of consumption of energies and temperature).
For the architect, a list of values or a table of figures does not necessarily speak the same way or indicate what a drawing does. In addition to that, there is the flow and the nature of information, which is not the same for the various speakers in the act to build.

L'environnement de simulation
The regulation of thermal environments has for objective the improvement of user comfort while decreasing energy expenditure. Thus from this point of view, control of the physical parameters is essential.
"Understanding is knowing which cause has which effects, by which means, at which rate ". [4]

Knowing that each interaction in the building is known by the specialists and the researchers, the tools which deal with it are brand new. The majority of the good approaches failed due to the complexity of the energy phenomena. This situation created constraints in the process of the computer-aided design, and gave a bad image to either to the project superintendent or to the building owner.
One of the causes of this situation is the number of middlemen in the building process. The nature of the tools proposed is not well adapted to reality and cannot meet the needs specified for the design.

In response to these problems, much of tools for simulation were born, ranging from simplified tools to heavy (dynamic) tools which model the real world with increasing detail.
: Clarke and Maver[5] established the following classification:
· 1 st generation: Each tool is documented, with analytical formulations, with one part taken for simplicity, fragmentary in the approach, providing results with a minimum of constraints.
. 2nd generation: These tools are characterized by the response times of the wall and spaces. They do not take into account the treatments of air movement, the systems (heating/air conditioning) and their controls. They are characterized by the ease of use, a closed interface (not of extension) and their low price.
3rd generation: They are characterized by the treatment of the interactions between the zones, by using numerical and analytical methods. These tools require considerable expertise and resources to solve simple problems. The interfaces can pose some usage barriers. They are often produced by teams of research and development for their own use (house use).
4th generation: these tools are characterized by how they start to integrate the building design (elements of the CAD), containing advanced numerical methods which make it possible to evaluate the performance of the building and control lasting simulation. Interfaces and the fundamental models of evolved data are developed to present and treat entities of simulation as well as objects. The common denominator of this generation is the integration of the knowledge bases in the infrastructure of the tool.

The first and the second generation are designated by the name of simplified tools because of their treatment focused on fundamental physics
The third and the fourth generation are designated by the name of tools for detailed simulation. The tools which are focused on a field of specific studies (for example CFD[6], calculation of bridge thermal, design of glass systems) can enter one or the other category, according to their physical and digital processing.
STUDIES AND NEEDS.
"An increasingly large need remains in the energy effectiveness of the buildings, but it is unfulfilled by a lack of interest, and lacks incentive and understanding of what is possible and required to carry out these projections" [Selkowitz 1992]». [7].
Energy and environmental effectiveness is fundamentally based on luxury on the priority list of the designer. If we want to achieve continuous progress towards this effectiveness we thus need strategies which combine tool effectiveness, comfort and productivity.
It is necessary to encourage the designers of tools and simulation environments to supply support for the decisions of design and to provide information in clarified forms for the experts, such as the accompaniment of the execution of the tasks by the intermediary of diagrams and explanatory graphs. An ideal tool of building design should:

. · Be interactive with the designer in order to be easy for the various users and various qualification levels.
· Bring up to date information in a suitable format for the architects.

. · Provide efficient access to large databases (tools which make Gigaoctets of data available to the designer will not help to solve real problems unless the data can be recorded, searched and handled easily).
· Provide design advice, expert opinions and technical support (a hotline).
». From an architectural point of view, HOWRIE [8] remarks: "Currently, it is evident that architects and engineers implement effectively separate processes in designing the same building. The language, the concepts and the lines of thinking of each one are hardly recognizable by the other ".

To try to determine the problem, workshops of study and evaluation were created. The first workshop took place in August 1995 in the United Kingdom; its mission was to reach a consensus in the applicability related to the building, the capacities and the methods of application of simulation from the point of view of the developer and the expert as regards the tool.
: The principal identified goals were:
· To facilitate collaboration and to integrate it between intervening agents in building design.
. · To train and update the students and the experts.
. · To evaluate the thermal regulation, conformity of check code and to evaluate incidences on the environment.
· To emphasize capacities of the tool in terms of modeling and treatment of the air, flexibility in modeling (moisture, multidimensional momentary conduction and daylight).
· To adapt interfaces to the level of the user and the stage of the design process, and to provide intelligent libraries by default (of components and object-oriented representations).

es : The second workshop was dedicated to the users of the simulation tool and concentrated on requests for improvement of the Man/Machine interfaces. This workshop came out with following requests:
· the assumption of responsibility of the environmental problems in the design.
· the integration of catalogues and manufacturers' libraries in the tools.
· the economic factor and analysis.
· the emphasis on the capacities of the tool in terms of interaction of external wall/environment (validated models of thermal transfer and movement of air).
· interoperability with other CAD tools, flexible component libraries, online help and the capacity to personalize inputs/outputs (reports/ratios).
Other points were underlined by the simulation tool experts:
· simulation is very expensive.
· simulation requires many means.
· simulation is necessary only for the evaluation and audit boards.
· There is much difference between what one simulates and reality.

Even if the sums invested for simulation are very low, the designers' idea has not changed; they establish a link between the complexity of the operation and its cost. For this reason the designers and the Study Bureau are limited to investing in the tools known as first and second generation (simplified tools).. These tools are adapted for exploration from the beginning of the design where descriptive information is limited and the identification of the trends is required. The market provides all the tools which the design teams can use.
. As the project evolves, the requirements as regards simulation become increasingly complex. The details of the façades, the auxiliary systems and the various interactions become significant, so a different class of tools is required

. However, the best practice of design isn't the frequent recourse to the detailed tools based on the third and the fourth generations. Many of these must make simulations with pragmatic constraints of the process of design.

CONSEQUENCES OF The USE OF The SIMPLIFIED TOOL DURING The ENTIRE DESIGN PROCESS.

A recent study undertaken in the United Kingdom has shown that the designer needs to access several tools at the same time, each one of these tools is adapted to a well-defined stage of the process or a particular question in this process.

"When the precision and the degree of affinity of modeling decrease, much of data output is degraded or ignored. The methods become indicative, nonpredictive, the application is limited, nongeneral and it results in a lack of integrity with respect to the real world ".

. The first and the second generation of tools are used in the sketches (the draft), at the moment when the project is not very researched. But at the time when the project advances, it starts carrying a significant quantity of information. On the one hand, this type of simplified tool can no longer continue to manage this significant flood of information, on the other hand, they no longer answer the innumerable questions with which the designer is confronted.

It is at this time that one makes the choice of a detailed tool,

To be in conformity with these recommendations, there are two possible alternatives:

To update and evolve an environment of simulation, if the environment allows it · Put into interaction several tools the designer needs, from the simple to the detailed, taking into account the complementariness in the execution of the tasks and the role of the design process.

THE FUTURE OF SIMULATION

Simulation is defined now by a better approach in design practices, it constitutes a passage impossible to circumvent for those wanting to validate their projects.

. certain establishment, the CIBSE in United Kingdom and the CSTB (EVL) in France have long supported the use and evaluation of data processing tools dedicated to building in the schools, the research centers, and the Study Bureau, starting to identify the product in the public market, making some evaluations and some real tests and wishing to guide their members in the selection and the use of such tools.

The introduction of the simulation tool into the design process is supported because: The designers explore new concepts in architecture, the construction industry, the systems and the relationship with the environment (HQE, CO2), which are not within the range of the methods and the correlations of the simplified tools.

?. The question being asked is: can the use of simulation be continuous throughout the process of design, without requiring expensive concessions on behalf of the teams of design and without compromising the quality of the simulated object, which is the structure?.

Many designers of simulation tools claim that their programs offer substantial functionality in support of the design process. They invested heavily, by equipping their tools with easy-to-use interfaces able to tackle questions of a greater complexity.

Another question arises: has the arrival of inexpensive, powerful and sophisticated interfaces, really removed the mystery and the complexity from simulation?

Le gestionnaire du projet. THE PROJECT MANAGER

The best practice in design tools is to envisage an integrated environment which controls a palette of tools. One can consider the building like a subset of interactions, where each tool is given the responsibility to study and evaluate such or such interaction. The subset of the thermo physical interactions is represented in the diagram below.

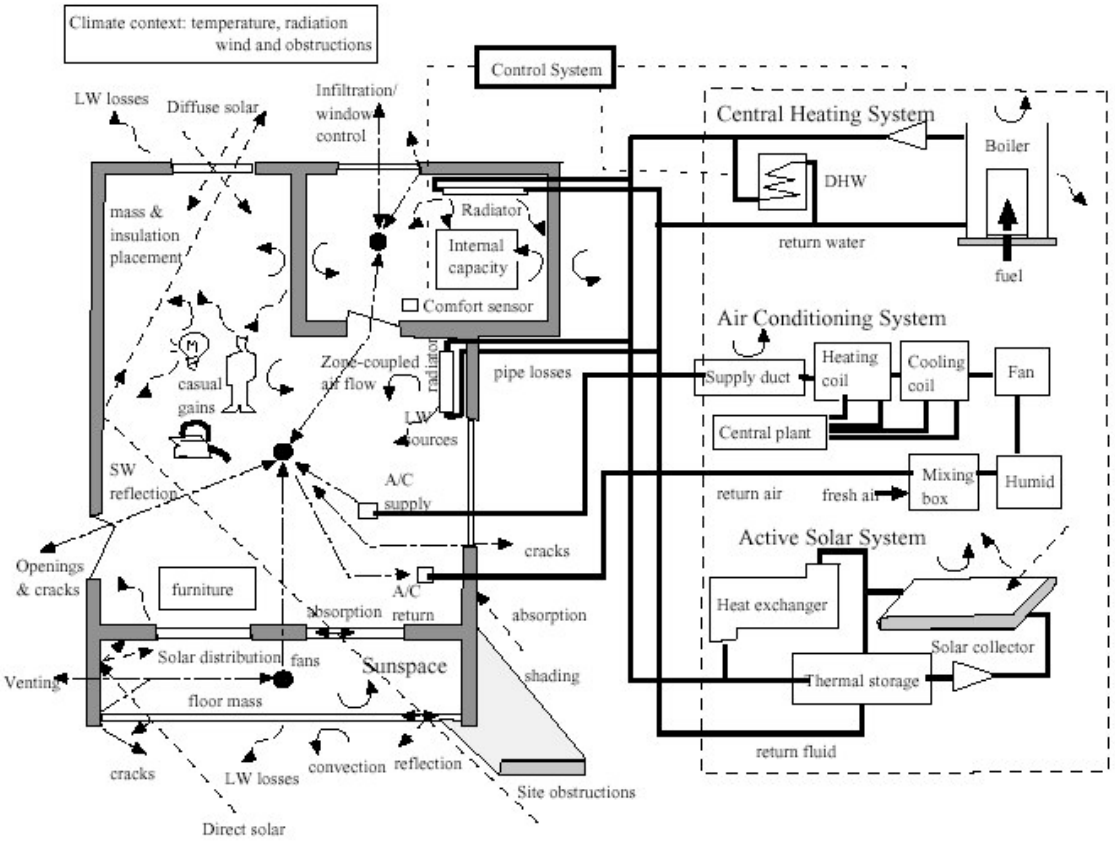


Figure II : éléments à gérer en simulation

. When an environment (building) is subject to the changes of terminals under certain conditions, control and configuration also change, its thermo physical state evolves according to the laws of physics and dynamic flows of energy via convection, conduction and radiation as well as air circulation; it results thereafter in changes of temperature or variations in pressure.

. Such interactions are omnipresent and exist independently of the size, geometrical complexity or the composition of the design. The choices made during the design process influence the course of the study and the quality of the results, which contribute thus to a certain degree of viability in the project; whether it is marginal, acceptable or exceptional.

THE ENVIRONMENT OF TOMORROW.

It is for this reason, and it is not the least reason, that it is necessary to think in total terms when one speaks about the simulation tools, it is necessary to think of making a set of tools interact by means of an environmental project management interface (window, application) in which one can find:

applications and principal data models of the environment regarded as objects by the user and containers of information associated with all the phases of the life of the design project.

a light and accessible interface.

online support and a metaphor of tools like a central office.

a visual tool can also be integrated for the thermographic and visual evaluations of light.

The manager of the project must be put to the test under extreme conditions; various complex projects will then be examined in the case of a project study of an increased complexity. Once these conditions are met and the tests are successful, including the integrated evaluation of the execution and the co-operative use of the various tools of design, we will be able to validate the effectiveness of such an environment in practice of simulation related to architectural design.

: The management of the simulation projects is then extended by the inclusion of orders, based on the knowledge of the process modelled in an integrated conception system. The work proves that the effectiveness of simulation in the process of design is emphasized by:

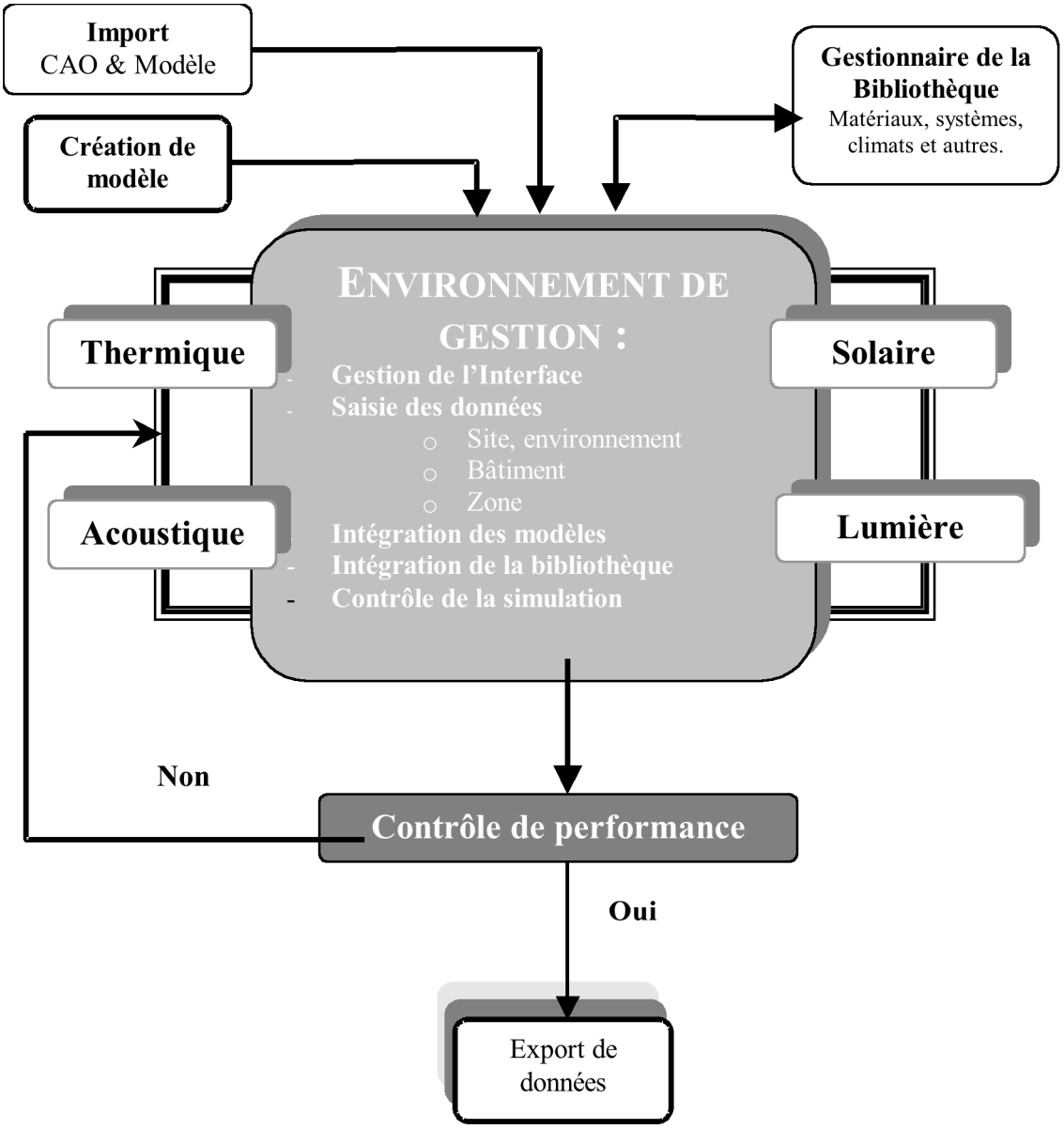
· the use of progressive exercises in the formal seizure and qualification.

. · guided formation for the experts.

. · access to an interval of exemplary models.

.

The managers of the projects based on simulation are able to gather a multitude of tools appropriate to simulation and to convey knowledge to the user by means of the suitable form the environment.


Import
CAO & Modèle
Création de modèle
Gestionnaire de la Bibliothèque
Matériaux, systèmes, climats et autres.
ENVIRONNEMENT DE GESTION :
- Gestion de l'Interface
- Saisie des données
o Site, environnement
o Bâtiment
o Zone
Intégration des modèles
- Intégration de la bibliothèque
- Contrôle de la simulation
Thermique
Solaire
Acoustique
Lumière
Non
Contrôle de performance
Oui
Export de données

The current goal of the work undertaken in units of research on several environments of simulation[9] is to explore the aspects of the design which were not well defined by the practice of existing tools. Having tried to organize formation around the tool in order to well determine the nature of the barriers met by the current use of simulation in the design process. Such observations and alternative approaches were tested on a simulation environment which attempts to meet the needs of the designer.
Références.

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Sustainable investments in Poland – The need, the profit or the luxury?

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1. INTRODUCTION

In modern global economy it is **investment** (in the meaning of allocation of capital) that develops sustainability or causes insustainability. Sustainability can be introduced by special means of country's or regional policies, which may have different form such as legal, organisational, financial, fiscal, educational, or other. All of them are finally focusing on creation of willingness to pay (WTP) for sustainable investment. The WTP as seen by economy is interpreted in cost and profit language where the discount rate is a main factor for taking the investment decision. It is reported, [1] in relation to energy conservation investment, that WTP depends on market value of available rates and it accepts lower then market rate with increase of investor financial wealth's. The neoliberal economists say that political intervention into economy causes market failures. Market forces are belived to take into account and enforce the need for sustainable environment themselves, if we do not disturb the supply–demand interaction. This could be a general true, provided that the value of products on a market (as opposed to market value) reflects all of related environmental costs. Due to the competition most of the producers do not count these costs into the final product's price, because quality of environment is still considered as a limitless good for individual enterpreneur, even if it is not true for global balance.

This article discusses some aspects of WTP based on experiences of two different ways of introducing the sustainability to Polish market. The first one comes from legal category, where the adequate act of law has been accepted to support WTP for modernisation of existing buildings, and the second one is a international demo project which used subsidizing for backing up the GHG reduction investments. So far, both of them did not developed enough to bring predicted results. Both of them failed to propose enough to create expected WTP of investors. The opposite experience is reported from summaries of EU RTD Vth Framework programme, where the WTP has been triggered by 1/3 of the support given to the investors. The explanation and analysis of this fact could be very comprehensive, inhere we try to find a simple correlation between WTP and an overall Environmental Sustainability Index as it is defined by An Initiative of the Global Leaders for tomorrow Environment Task Force, World Economic Forum. [2].

For beter understanding of presented here programmes recently developed in Poland it would be helpful to present the overall situation of Polish building sector.

2. BACKGROUND - BASIC INFORMATION ABOUT HOUSING IN POLAND.

According to 2001 data Poland has approx. 12 million housing units with the total usable space of approx. 710 million m^2.

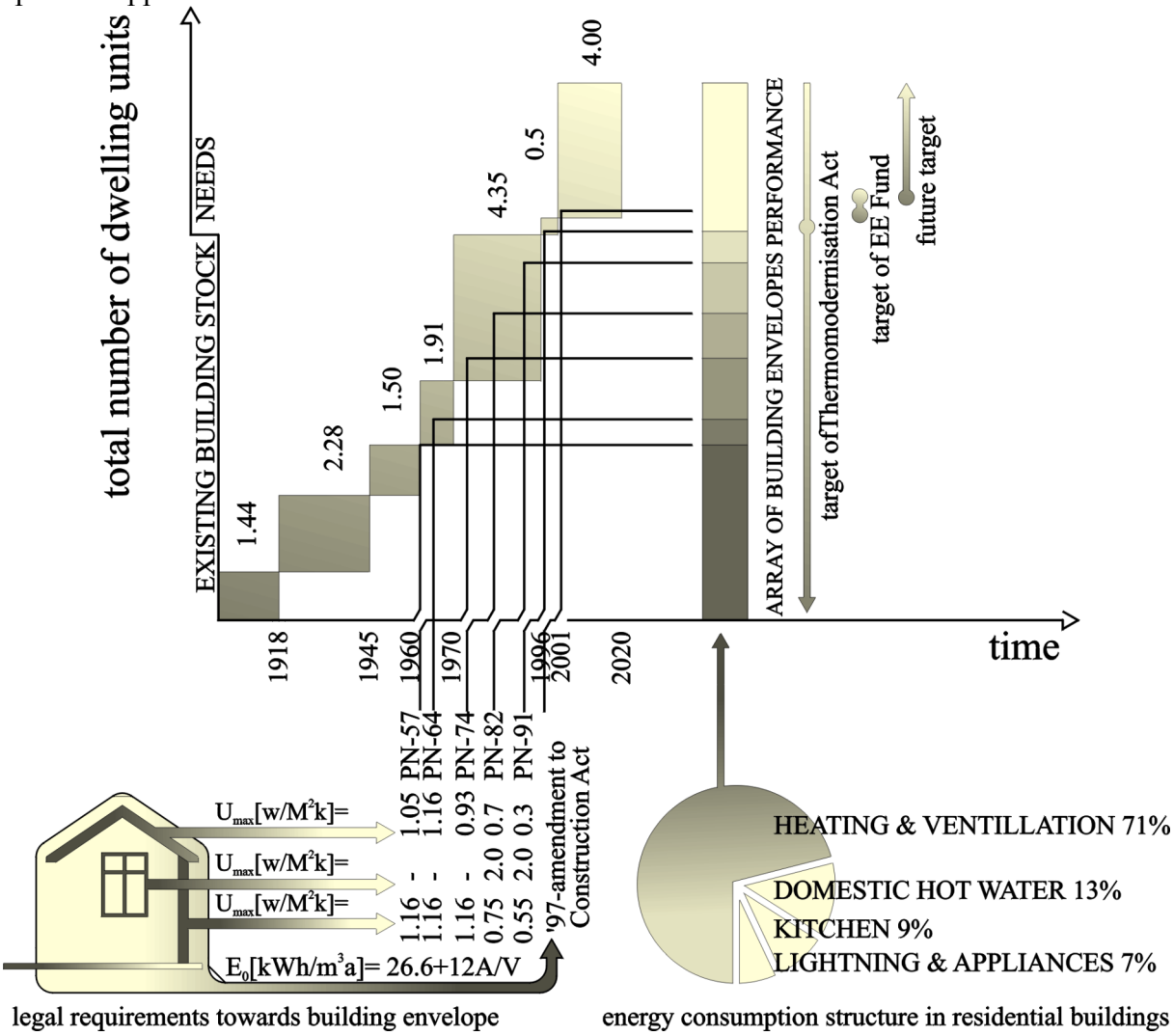

Figure1. Importance of energy saving measures on the background of existing and predicted numbers of dwelling units in Poland.

The scale of recent construction in Poland is far below the needs and reaches approx.80 thousand units per year. In order to achieve by the year 2020 average European 400 units per 1000 inhabitants, 200 000 apartments should be constructed per year. There is a strong need for new housing in Poland (there are approx.300 dwelling units per 1000 people), so it should be expected that sooner or later it will result in intense construction activity. Considering the data shown in Figure 1 it is obvious that thermal modernisation of existing buildings and modernisation of their systems to reduce energy and water consumption is most urgent. On the other hand, there is a chance to balance housing deficiency with new, sustainable buildings.

To help to overcome problems of modernisation of building stock, Polish government introduced special financial mechanism to improve the investors' ability to undertake the investment in energy saving measures.

3. THE THERMOMODERNISATION ACT

Thermomodernisation Act established by Parliament on December 1998, with latter amendments in July 2001, called into being the Thermomodernisation Fund. The Fund is an institution financing – in form of thermal modernisation bonus – the projects aimed at the improvement of buildings envelope, internal technical systems, local energy sources and distribution networks. After fulfilling terms of the Act, the investor using bank credit for thermomodernisation is granted a bonus. The bonus may reach up to 25% of the credit raised for the investment, and is paid by the Fund to the bank servicing the credit after completion of construction. (Previous version of Act, set up the bonus release after repayment of 75% of the credit with the regular interest rate). It is significant decrease of the cost of investment. The premium is paid only for measures which fulfil condition concerning level of profits, the type of modernisation activities and its economic result. The bonus may be granted both to the owners or administrators of buildings, and operators of local heating networks and central (town) heating plants.

The programme to support termomodernisation showed moderate investor's interest and its development has been criticised by different groups. Financial resources dedicated every year for the Fund remained not spent. This can be explained by different barriers related to thermomodernisation, one of them is poor attractiveness of offered support from investor's point of view. This results in investors' hesitation to undertake the investment. However, in other countries programmes less supportive are gaining higher interest. This interest is connected with WTP (willingness to pay), and in case of Poland it shows different priorities of investors. These priorities are related to economical, social, environmental and educational situation of the country, partly explained by the correlation of elements of ESI – environmental sustainability index.

The programme of thermomodernisation is dealing with existing buildings, whereas the improvement of building standards over the ones in power is a scope of the project undertaken by Global Environmental Facility and related to the new construction..

4. GLOBAL ENVIRONMENTAL FACILITY PROJECT

In a five-year period (1997-2002) over 10 new-built housing projects in Poland underwent the process arranged by Global Environmental Facility (GEF) demonstration project - the Energy Efficiency in Buildings component [4]. GEF project was tailored to specific needs of Polish housing construction given the name of Energy Efficiency Fund for New Residential Buildings. Main resulting arrangements were as follows:

- EE Fund would grant-finance 100% of incremental energy efficiency and conservation measures, i.e.: extra improvement above the current Polish building code.
- EE Fund would be provided to applicants who have secured construction financing
- one of the strict requirements to be met by granted projects was cost-effectiveness of extra features. That means, the cost per unit of conserved energy had to be lower then cost per unit of electric energy on the market. Given that, several extra features were successfully applied in new designs. The most efficient of them are:
- an additional insulation of walls, roof and basement floor, above that required by Polish regulations combined with high thermal efficient windows and doors
- mechanical ventilation system with waste heat recovery
- passive energy collecting features incl. solar energy and recovery of waste heat from technical systems
- detailed energy audits revealed very promising energy savings (up to 90%+ for the combined systems) and reasonable incremental cost efficiency.

Investors applying for the EE grant were to undergo complicated and time-consuming process of auditing construction projects, accepting applications by GEF Project office, co-operating with auditors and supervisors. What's more, it was the investor's financial risk, since it was the investor who was to secure all the construction costs including incremental cost of energy-conserving extra features before grant was paid after successful completion of recommended measures.

Considering GEF Project through **PPP** (place-product-price) principles of marketing we can identify some of its barriers. The product here is the environmental performance of building successfully achieved in over 10 realised projects, so we take this variable as constant value while the other two – place and price are subject to further manipulation.

Price needs some comment. As it was said before, the grant was paid after the completion of construction. For that reason no cost of money was considered in the cost-effectiveness of the energy measures. This is an important factor in face of economical facts in Poland, where the interest rates oscillated at figure of 25% at that time. The cost of money was paid by investors, but it was paid along with energy audit, and both should be somehow additionally included in the grant e.g. as a part of incremental costs.

"Place" is most controversial. It seems that programme could be better disseminated. As a result of the lack of information many potential investors were unable to undergo the procedures required by GEF Project Office in a time, even if they were able to provide extra money for incremental initial cost. The predicted high interest of investors caused that the programme designers had not reserved resources to market the programme.

Table1: Costs and Benefits of the 2 Groups of Energy efficiency Strategies

Unit type	Energy savings	Incremental construction cost	Cost of Conserved Energy	Simple Payback (1)	GEF Cost - effectiveness
	%	zł/m^2	cce (2)	Years	USD/tonCO_2
Group 1: Improved insulation and windows:					
Townhouse	27-34	14-31	0.054-0.083	2.2-3.3	19-26
Multi-unit	21-32	17.1-23.1	0.136	1.6-5.4	15-81
Group2: Mechanical ventillation, waste heat recovery and control, plus improved insulation and windows:					
Townhouse	68-75	148	0.158	6.3-7.7	42-45
Multi-unit	63-77	75.9-98	0.1-0.144	4.6-6.7	76-130

Simple Payback = (Average Cost of Energy Consumption – Given Cost of Energy consumption) / Incremental Construction Cost (1)

- using the national cost of electricity as the base (0.18 – 0.2088 zł/kWh – depending on year of analysis).

$$CCE = (\Delta \text{ Cost} / \Delta \text{ Energy}) * (\text{discount rate} / (1 - (1 + \text{discount rate})^{-n})) \quad (2)$$

- discount rate = 0.12, and n = 50 years.

We can measure success of main goals of the project by two indicators of achievement: the quality of experience and the scale of it. The quality of experience means effectiveness of dissemination of technical and organisational solutions, while the scale of the programme means recorded repeatability of implemented ways of development countrywide. Taking this definition as a basis we can conclude that the EE project did not perform in a predicted way. The programme did not attempt directly to help investors to overcome the barrier of higher

initial cost, but their willingness to pay (WTP) was enforced by expected refunding despite the risk that they would not comply with final requirements of detailed procedure due in time and sophisticated technology.

5. THE FIFTH FRAMEWORK

Described above, two financial mechanisms have failed to fulfil their objectives in extent. Thermomodernisation Fund and GEF did not attract expected interest of investors despite the pedicted financial attractiveness. Within a Fifth Framework RTD European programme financial mechanism which facilitated implementation of demonstration projects of new technologies, approaches and solutions under the thematic programmes existed. This mechanism rule was that up to 35% of incremental costs could have been refunded. A number of projects underwent this procedure, and according to reports summarizing Vth Framework the proposed mechanisms has been widely accepted and used among the European Communities member countries. This means that remaining 65% of money invested by the applicants came from other private or governmental sources. The overall tendency is the increasing direct financial participation of investors. This could lead into the conclusion that the WTP of investors from countries of European Communities is at least as much as 65% of marginal costs for new technologies, even if the market value of the investment in energy saving measures is far below the interest rates.

6. CONCLUSIONS

The WTP is a complex factor and depends on level of income (GDP per capita), education of society, traditions, externalities (meant as the characteristic of local environment), health, and many other social and technical aspects. The WTP reflects an ability of society to participate in environmental sustainability development. For the purpose of this article differences of WTP of individual investors were analysed on the socio-economic backgrounds. It is clear that the performance of economy expressed by WTP of individuals is a key factor predicting success of sustainable development in the market economy. WTP reflects adequacy of particular mean to support sustainability. Adequate means result then in broader response of individual investors, and the final success is measured by the scale of undertaken investment in sustainability. The differences in WTP of investors in less or more developed countries seem to be easily explained with the rule of hierarchy of needs – the more basic needs are first to be fulfilled.

This correlation is at some degree revealed in “Environmental Sustainability Index” [2]. ESI is a measure of overall progress towards environmental sustainability developed for 122 countries. A high ESI rank indicates that a country has achieved a higher level of environmental sustainability, a low ESI rank signals that a country is facing substantial problems in achieving environmental sustainability along multiple dimensions. Poland’s ESI score is much lower then these of EEC countries. Attraction of investor interest in case of countries with lower ESI requires more favourable conditions then for the countries better rated. This conclusion can provide some guidelines for designers of terms of Sixth Framework to distinguish co-financing of demo project in relation to ESI, if the same rule will be attained.

ESI reveals that there is a relationship between income and environmental sustainability. The 35% of refunding marginal costs of demo projects in Fifth Framework proved to be adequate subsidy to trigger the WTP in European Communities. At the same time much more attractive programmes established in Poland did not get significant interest – they did not generate

expected WTP of investors. It is clear, that greater WTP will occur if we create greater individual demand e.g. by:

- having bigger per capita income
- promoting individual awareness of importance of energy savings
- proposing individual financial benefits
- pointing out benefits for individual health and comfort
- dissemination of opportunities and means

Statistical data proved there is no straightforward correlation between the need for high quality environment and investment decisions. Construction sector in Poland encounters problems originating from economy transition from central management to free market. Because of deficiency of flats, the demand for housing is coloured by the strong need for more space for people to live in. The initial cost of investment is then vital, because it is the total amount of usable area what is demanded at first. Primarily it is usable area and location but not the cost efficiency of energy consumption that calculates NPV value of a flat. People do need a high quality environment, but it is a false assumption that they would be therefore interested in investment in environmental performance of technical systems. If they want better environment they choose more comfortable location.

There is a lesson gained from financial incentives introduced in Poland, that it is not always adequate to generate sustainable development by enforcing investors' WTP for energy saving solutions. Economists would probably argue that this is because such incentives were not aligned with market forces. Authors of this article share that point of view. It proved that market forces are not capable to resolve global energy deficiency in forseen future [1]. This is because the individual demand for high quality environment is not necessarily associated with energy efficient investment - the comfort of an individual is limited to his own living space. In the market economy there is inequity of distribution of high quality environment. We can see that logic in Polish experience if we profile the investors that yielded WTP required by GEF programme. Sustainable development is possible under condition that energy saving will be the rule for all, not a luxury for the chosen. Financial incentives aiming to trigger WTP of individuals in the poor market sector, like construction of new houses in Poland must be ineffective due to their inadequacy to the people's needs. The failure of GEF and Fifth Framework in Poland comes from unrecognized conflict of individual and public interests.

Individual investors would respond for financial incentives if they were aware of and share the social need for sustainability and have their other needs satisfied. So the final conclusion is that we shall cure the causes of unsustainability like low environmental end economical awarness and low institutional capacity along with market interventions.

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Building and Construction Industry in a Paradigm Shift?! - Status and Driving Forces in Norway

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1. INTRODUCTION

The building and construction industry have a major environmental influence. In Norway, both the total energy consumed and the use of electricity for heating purposes are a challenge. 36% of the energy consumed in Norway is used by the building and property sector. As far as waste is concerned, avoiding waste, handling of waste, and the toxicity of waste are challenges to be faced, according to a report published by OECD/GRIP/EcoBuild (2000).

To know more about the industry's response to the challenges, GRIP/EcoBuild and the Norwegian School of Management (BI) have conducted a survey addressing the managers' perceptions of driving forces, obstacles, attitudes plans, actions and results.

The survey, called GRIP barometer, is covering some service and production industries in Norway. The focus of this paper is on the building and construction industry, including architects and real estate brokers. This study has previously been conducted in 1996 and 1998, and some trends will be elaborated upon.

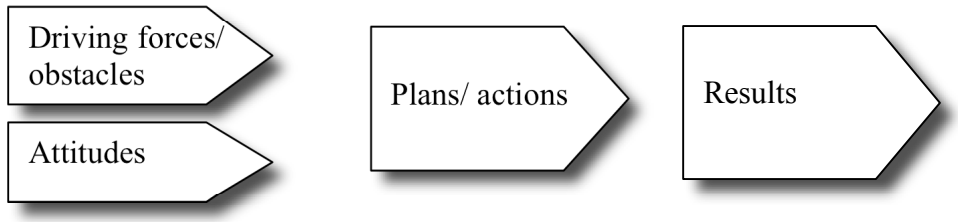

Figure 1 Structure of the Survey (Miljøbarometeret, 2001)

2. ABOUT GRIP BAROMETER

GRIP/EcoBuild (Adviser Katharina Th. Bramslev and Adviser Sigve J. Aasebø) have conducted this survey together with the Norwegian School of Management (Professor Bjarne E. Ytterhus and Research assistant Kjetil B. Grønmyr) for the 2002 version for the building and construction industries.

2.1 Questionnaire and Data Collection

Two questionnaires were developed, one for the Building Industries (companies producing or assembling building materials), and one for the Service Industries (companies providing services to the industry, like architects, consultants, etc.). GRIP/EcoBuild used NACE-codes to pick industries to be covered by the survey. The companies within these industries were randomly picked from a database provided by a professional data gathering company. The population covers companies with more than 20 employees. In mid May 2002, the

questionnaire was sent out. Non-responders where urged the to fill in the form during June, using telephone.

2.2 Industries Covered and the Response Rates

Table 1 Industries and Response Rates

Industry (with NACE-codes)	Questionnaires sent	Questionnaires received	Response rate
Building Industries	*235*	*62*	*26,4%*
45.1 Site preparation	79	24	30,4%
45.2 ”Civil engineering”	79	22	27,8%
45.3 Building installation	77	16	20,8%
Service Industries	*148*	*42*	*28,4%*
70 Real estate activities	73	23	31,5%
74,2 Architects/engineering/ technical consultancy	75	19	25,3%

3. FINDINGS

3.1 Driving Forces and Obstacles

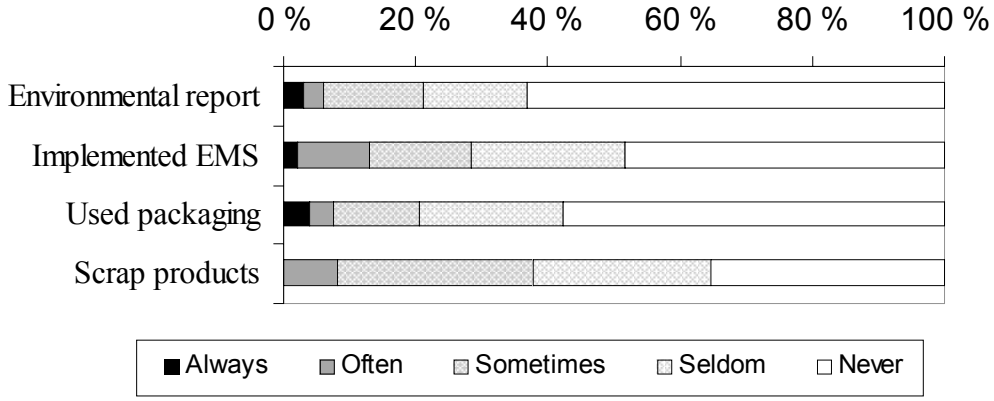

Figure 2 Customer Inquiries for Building Industries (EMS = Env. Management System)

- 35% of the companies never experience their customers inquire information about environmental practices of the company, in the Building Industries.
- If the customers want information about the company’s environmental practice, the most common area of interest is how they treat scrap products.

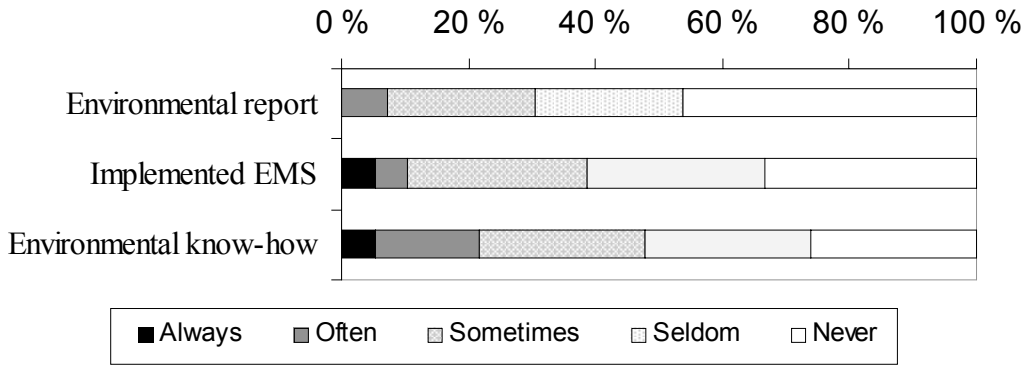

Figure 3 Customer Inquiries for Service Industries (EMS = Env. Management System)

- Customers in the Service Industries inquiries more than the customers in the Building Industries.

3.2 Stakeholder Pressure

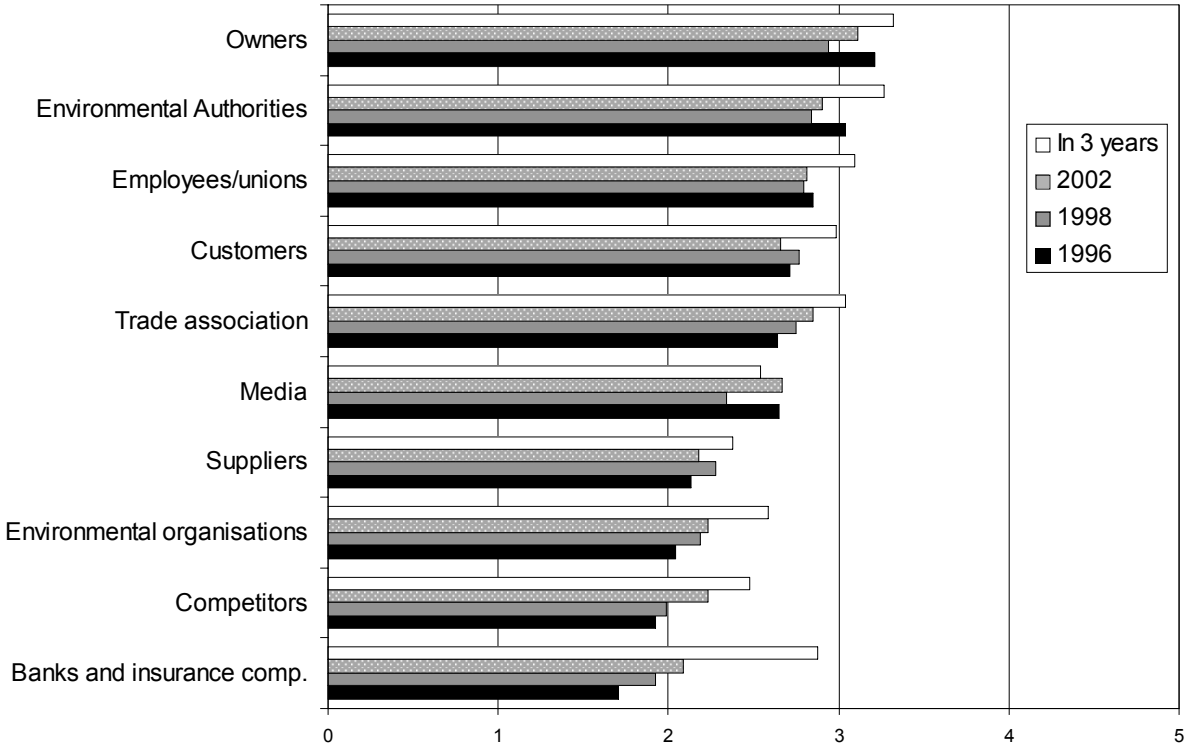

Figure 4 Stakeholder Pressure Making the Companies Implement Environmental Actions

- The most influential pressure groups are owners, environmental authorities, employees/unions, customers and trade associations.
- Insurance companies have a greater influence on the construction industry than the banks. This difference is expected to increase in three years time. This change is substantial.

3.3 Attitudes

Table 2 Attitudes in the Building and Construction Industry

	1996	1998	**2002**
Environmental problems are very serious and one of the largest challenges of the society	87%	87%	**92%**
Market conditions considering the environment will make us more competitive	64%	70%	**76%**
To solve the environmental problems we need more strict regulations	56%	71%	**73%**
Investors, banks and insurance companies will more often judge how companies have resolved their environmental challenges	54%	55%	**55%**

- The need for a paradigm shift is rooted in the managers of the industry. 92% believe the environmental problems are one of the largest challenges of the society.
- Stricter environmental regulation is important to solve the problems, according to 73% of the respondents.
- The financial service sector is expected to focus more on how the companies have resolved their environmental challenges.
- 76% of the managers believe changes in the market, reflecting environmental challenges, will increase the corporate competitiveness.

3.4 Actions

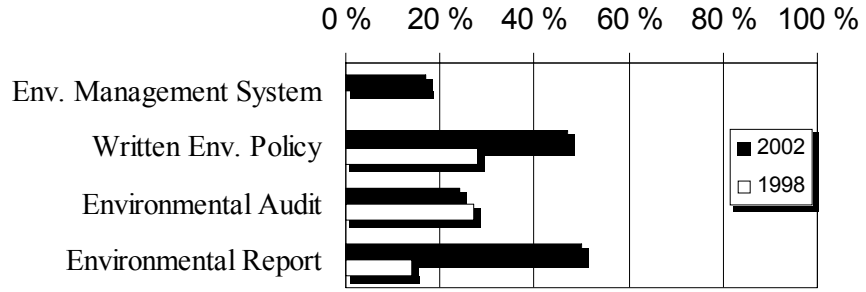

Figure 5 Environmental Action in Building and Construction Industry in 1998 and 2002

- There is a large increase in the number of companies releasing an environmental report (from 14% to 50%)
- 47% of the companies have a written environmental policy in 2002, whereas only 28% had the same in 1998.
- Only 17% have an environmental management system in place.
- The environmental plans and actions are increasing, but far from a level able to make the industry go through a paradigm shift.

3.5 Results

3.5.1 Environmental Action in Own Buildings

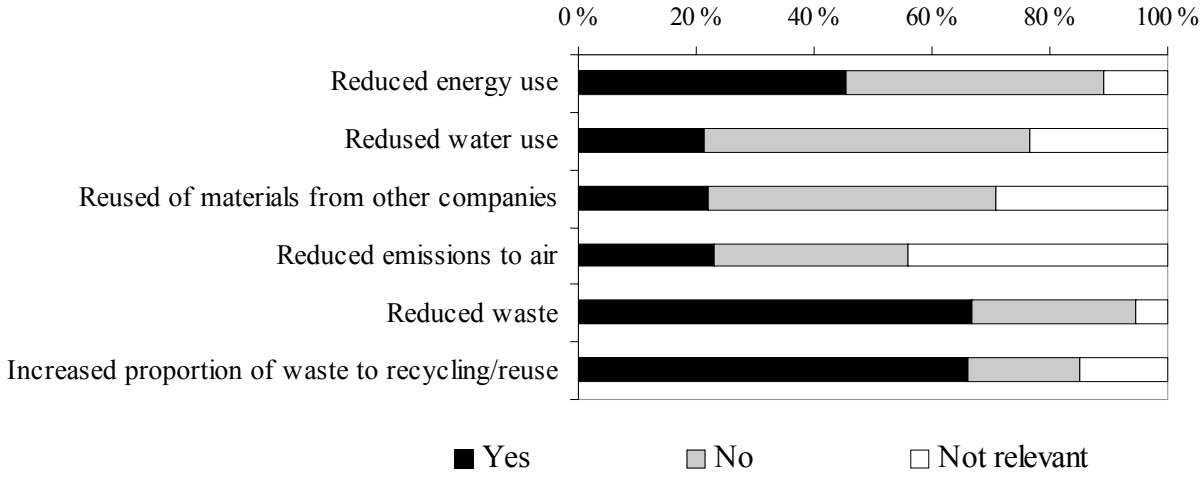

Figure 6 Environmental Action in Own Buildings

- Waste and energy reduction are major issues
- Data not disclosed in Figure 7 shows that companies within the Service Industries have done significantly more on reduced energy use in their own buildings than companies within the Building Industries.

3.5.2 Environmental Action on Products in the Building and Construction Industry

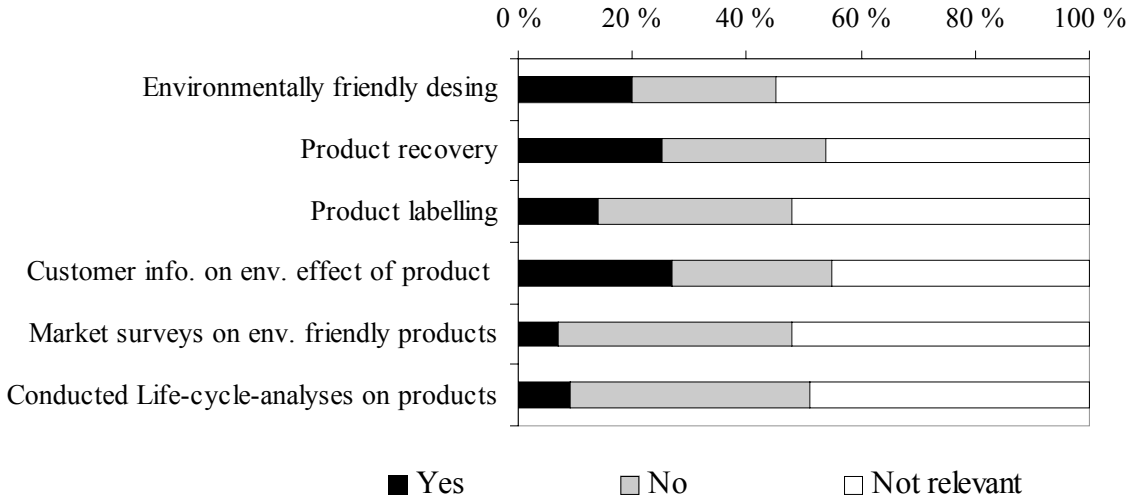

Figure 7 Environmental Action on Products in the Building and Construction Industry

- Approximately 50 % of the managers find questions about “products” “not relevant”.
- Customer information of the environmental effect of product is the most conducted action
- The Service Industries and the Building Industries gave similar response on these questions

3.5.3 Environmental Action in Building Industries

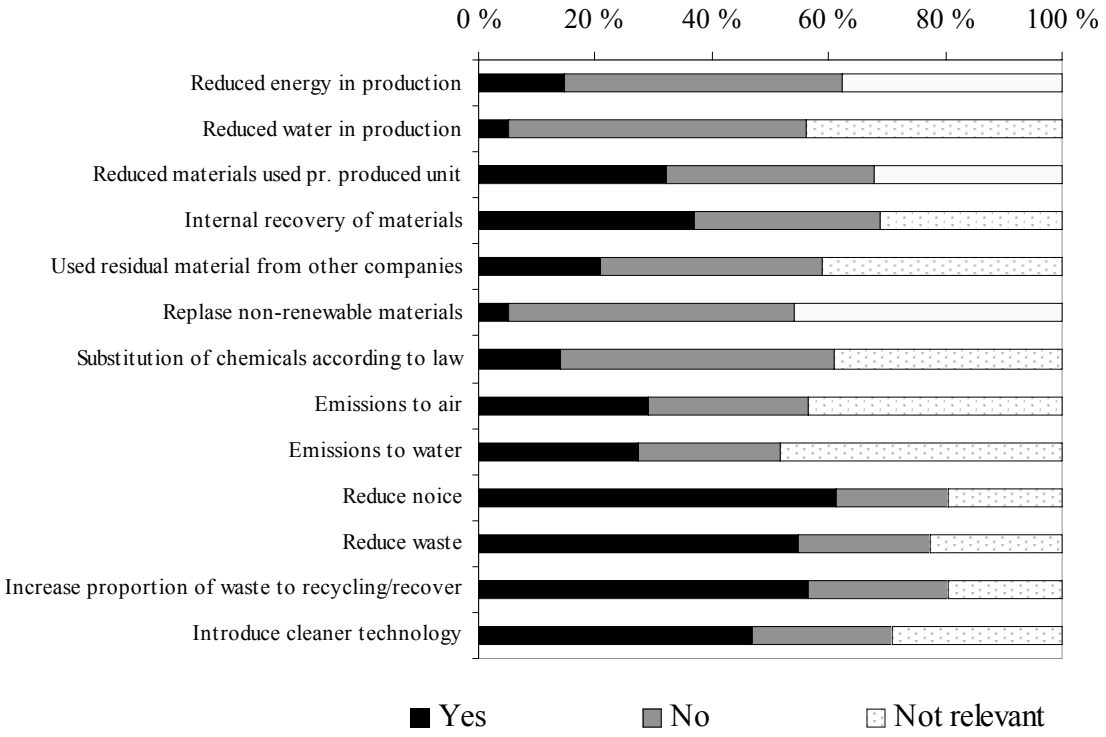

Figure 8 Environmental Action in Building Industries

- Noise and waste are the environmental issues most companies have been working on.

4. CONCLUSIONS

The main conclusions from the survey are:

- The managers in the building and construction industry perceive a need for a paradigm shift.
- The environmental plans and actions are increasing, but far from a level able to make the industry go through a paradigm shift.
- The expected pressure from the stakeholders is expected to increase within the next three years. Especially the insurance industry is expected to pick up momentum.
- Few companies (17%) have a systematic environmental management system, geared towards continuous improvement.
- The aspects with the most environmental action are those with the largest economic incentives and/or strictest environmental regulation.

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Ultimat – Building insulation from waste textiles

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1. INTRODUCTION

In Norway we depend heavily in textiles to keep our bodies warm, especially during our long cold winter. When these textiles no longer fill this purpose as clothes, they still may help us stay warm.

1.1 Development team and history: Over a span of several years our institute has been in close contact with a group of people who have worked towards the production of an insulation material based on waste textiles. The driving force of this work has been Fritjov Johansen. He has a background in civil engineering and building management connected to the Salvation Army here in Norway. One activity of the Salvation Army is collection of used clothes witch then is sorted, partly mended and resold. A very large portion of these textiles is sorted out and has traditionally been sent to waste deposits. Johansen saw the potential in using this portion as raw materials for building insulation instead.
In this work he has sought cooperation with two large house builders in Norway; Holstad Invest AS represented by Tor Erling Aasheim and Veidekke ASA. This last firm has a sub firm, Veidekke Gjenvinning AS lead by Ole Skytterholm, that is dedicated to and a forerunner in the reuse of different waste materials in our national building industry.

2. THE ULTIMAT MATERIAL

The Ultimat® material is a heat insulation mat that is suited for placing in wall constructions, in addition to use in tier of beams. Until now the market for this type of insulation has been totally dominated by mineral wool products. Organic insulation has been used in roof and tier of beams as loose fill insulation. Cellulose fiber has then been the most common material.
The unique feature of the Ultimat product, in addition to having very good insulating abilities, is that the mat is robust, flexible and at the same time able to keep its form and fill the cavity it is meant to fill. Workers placing the product will also acknowledge the comfort of not experiencing the itching and skin irritation we all are used to when working with some different insulation materials.

3. PRODUCTION

At present, only small-scale test production has taken place. The full-scale production process is thoroughly planned, location of factory and production equipment included. A very brief description of the production process follows:
Different types of return textiles is collected, sorted and stored at a few chosen sites around the country. The raw material is turned into a light fluffy material through use of shoddy machines, a well-known process for a long time. A certain quantity of synthetic textile fibers is mixed into the shoddy. The mat is then heated above the melting point of these polymer fibers. When the mat is cooled again, the melted fibers will have glued the rest of the fibers together giving the mat its robustness. This process is patented. In the production process it is possible to add chemicals to achieve certain goals, e.g. resistance against fire etc.

4. DEVELOPMENT AND DOCUMENTATION PROCESS

4.1 Properties score and comparison: Forming a background for the planning and decision process, our institute has taken part in collecting and presenting a list of important properties for the insulation material and given these properties score according to a certain method.
Many materials used in the Norwegian building industry have had a so-called NBI technical approval prepared for them. This document includes a list of properties and their corresponding statuses for the given material. These approval properties are not given a performance score but they have in this case formed a basis for the independent score list.
The score notation that has been chosen is well known; simply a number of plusses or minuses denoting whether the material scores very good or poorly for a given property. Judging what is good or poor could in many cases have been difficult, if we did not have reference materials for comparison. Luckily these reference materials, different mineral wool products, form one single group and this group dominates the market totally. Both the textile mat and the reference materials have some properties agreed on as not being perfect. Therefore it would not be a point in just comparing the textile mat with the reference. This would disguise the sought information. A better solution is then in stead to present the score both for the textile mat and the reference.

Table 1 Chosen properties used in the scoring list.

Health and security	**Energy and environment**	**Other / technical properties**
Resistance against fire	Heat insulation capability	Weight
Emission of dust and particles	Energy use during manufacturing	Compressibility
Emission of gasses and fumes	Content of reused waste materials	Moisture properties
Biological active content	Reusability	Resistance against biological growth and damage
Comfort in handling		Aging properties
Declaration of content		Mechanical strength
		Workability

4.2 Simple method: The score system is somewhat crude, but convey information in an easily recognizable manner. It was deliberately decided on not choosing a more sophisticated scoring system.
During the scoring process, this led to several discussions between the institute, as an outside observer and the team developing the idea and the product. This discussion was constructive in itself and clarified a lot of important points that demanded an agreed standpoint. The importance of accompanying the scores with some short textual notes stating important conditions soon became eminent.

In the following example, the scoring is dependent on conditions that may change according to new views on the subject among European authorities:

Table 2 Example of property scoring, illustrating the importance of textual additional conditions

Property	Ultimat	Reference insulation	Notes
Resistance against fire	+	+ +	Ultimat consists of burnable materials and must be treated according to this in regard to regulations...
Emissions of dust and particles			etc...

4.3 "Total score": The inevitable question would be whether the textile insulation is a "better or worse insulation material" than the reference material. Our scoring list does not take a standpoint on this. This has been a deliberate decision in order to restrict the scope of work to what was regarded as sensible for the process.
It was tempting, though, to count the total number of plusses that the textile insulation achieved and compare this with the number that the reference material achieved. This would of course give us a misleading answer. Some of the properties would be far more important than other properties and this is not taken into account with the simple method chosen.

There are more sophisticated methods that would give a better indication of total score. This is discussed later in this paper.

5. SUSTAINABLE INSULATION

There are a number of sustainability parameters that is commonly accepted as important. Sustainability aspects will bee exemplified connected to some of these parameters:

- Energy use
- Environmental load
- Use of materials and resources
- Health aspects

5.1 Energy use: Energy use may be regarded as one of the most important among sustainability parameters in our built society. Globally, energy use is linked to emission of CO_2, global warming and other unpleasant effects.
The energy used to produce the Ultimat material is roughly calculated to be 1/3 of the demand for producing the reference materials. This is a remarkable difference and gives the waste textile insulation good scores.
If we compare the energy use for production with the amount of energy that passes a normally insulated construction, we realize that the production energy heat, even for the poorest materials, equals the energy loss through the construction (dwelling in Oslo) during less than ½ year. The energy used for heating during the lifespan of a Norwegian building is very large and any good heat insulation material may then be regarded as highly sustainable.

5.2 Materials and resources: Pollution, growing waste deposits and other driving forces has led to a number of products in the building industry based on or partly containing waste materials. Mountains of collected glass bottles, problematic neon tubes etc. find their way into different very good heat insulating materials; staying in our field of interest.
Stowing away potentially problematic materials and at the same time relaxing the pressure on virgin raw materials serves a double purpose.

5.3 Environmental load: One special effect of deposing textiles and other organic waste in dumps is the resulting decaying and production of methane gas. This gas is a much more severe greenhouse gas than carbon dioxide. Burning the textiles, and in this way producing useful heat, is a better alternative, but this requires a suitable plant for this purpose and also a heat distribution system.
Keeping the carbon bound in the textiles while serving new purposes as a building material, in this way keeping the carbon away from the atmosphere for another say 50 or 100 years, is of cause the best solution.

5.4 Health: Textile insulation is composed of materials that surround us in everyday life. For this reason we may basically regard the material as totally unproblematic when it comes to emissions of dust, fibers, particles, gasses or fumes. In any case it would be the professionally equipped workers that either place the insulation material in the building constructions or who tear them down that would be subjected to any noticeable exposure of this kind, not the users of the ready built constructions.
Mould and other harmful organisms may start to grow in textiles being exposed to moisture for some time. The production process of the Ultimat mat includes heating of the shoddy to a temperature well above the limit that biologic active matter may survive. This sterilization is a useful byproduct from the production process.

6. DISCUSSION

6.1 Defining goals: In certain new buildings in Norway it has been decided on goals for minimum content of reused building materials. This has been quantified to a given percentage by weight. This does not favor insulation materials, having the one common property of being light in weight.
Defined goals are important. Modified goals based also on volume would correct the slight unfairness against insulation materials.

6.2 Additives interfering with the downcycling process: Changing the content of a building material may change different properties in a desired direction. It is in some cases very important to consider thoroughly to what extent one wants to follow this process.
One example: It is possible to design an insulation material with organic content but with additives making it inflammable to a very high degree. According to new international views, this may in the future make this kind of a material suitable in building constructions where fire regulations are very strict. On the other hand this will make this material very little suited as fuel for future production of heat in a combustion plant, as the last stage in a natural downcycling process. In very many cases this inflammability is of less importance, and the ultimate product would then be one with little of this additive.
The lesson one gets from studying this dilemma is that *allowing a possibility of diversity of properties may be a great advantage* in sustainable materials.

6.3 Total property optimization: Sustainable constructions will have to accept reduced inbuilt robustness in some areas. Some properties may contradict each other, as seen in the above example. Low scores in some property may be necessary, to give a good total score.
There are several more or less sophisticated methods that would give a good indication of total score. As a start, it is possible to give weight to different properties according to importance. The property score may also be translated to a numerical scale. Multiplying importance-weights with the corresponding scores and adding all the results is a simple procedure to acquire a total score.
This type of scoring system may become very interesting if one introduces *dependent scoring*. An example of this is when inflammability is more or less important depending on type of building and resulting fire demands.

6.4 System dependencies on material properties: The Ultimat material scores relatively low on properties connected to moisture and to resistance against biological growth and damage. Subconsciously following the same chain of thought as earlier, it was decided not to add chemicals to strengthen these properties. Important preconditions have been that good and secure building details are chosen, and systems ensuring clean and dry building process are followed. These properties are at present regarded as "good enough".
There will always be a certain uncontrollable risk of damages caused by moisture. This risk may be counteracted by various means. Systems of systematic inspection are realistic in many cases. In the near future moisture detectors probably will be as common as smoke detectors are today.

6.5 System of references: The lifespan of knowledge and views can sometimes be short. This has been experienced connected to health related properties in the Ultimat-work. We can demonstrate this from another organic insulation material. It has for a long period now had an additive to reduce fire risk and also reduce insects etc. thriving in the loos fill. The additive has been regarded as totally harmless, but is now placed on a list of materials with negative health aspects (the Norwegian "Obs-list").
A good materials declaration is important. A changeable system of reference to what someone responsible currently regard as the truth is usefull.

7. CONCLUSION

The Ultimat heat insulation mat has very promising properties as a sustainable building material.
The process of identifying, comparing and scoring different properties has in itself been valuable. This process can be aided by extended methods taking care of defined goals, situation dependant conditions and risk handling.

The chase for the ultimate insulation material for a given set of preconditions has ended, but the search for the overall ultimate insulation material will continue.